

/SSG/RED

SECRET



APR 1979

25X1



25X1

25X1

25X1

SUBJECT: CLEARANCE CERTIFICATION

VISITOR: [REDACTED]

CLEARANCE: [REDACTED]

CONTACT: [REDACTED]

DATE OF VISIT: 17 APR 79

PURPOSE: TECHNICAL DISCUSSIONS

SECRET

XXXXXXXXXXXXXXXXXXXX

EDM

GP-1

25X1

5

25X1



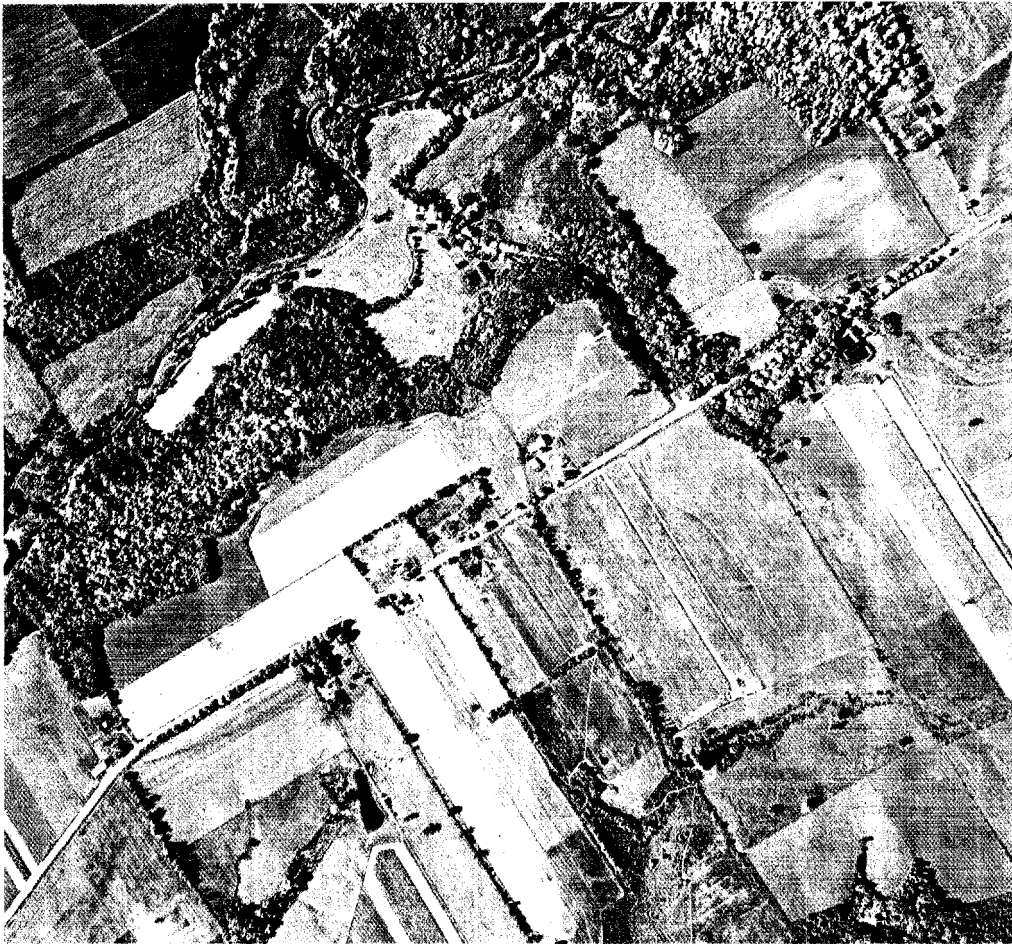
Apparently, [REDACTED] went to discuss subcontract on the CCC proposal.

SECRET

5

Declass Review by NIMA/DOD

Next 2 Page(s) In Document Exempt



Shoot False Color . . . *Color Infrared Photography* **Get REAL Information**

For special projects such as forestry evaluation, crop disease studies or pollution control surveys, shoot with KODAK EKTACHROME Infrared AERO Film and deliver *real* information to your clients.

Why? Because the false-color transparencies you get from this film show more than any black-and-white does, more than any natural color film does, even more than the naked eye can. They make it infinitely easier to spot crop disease, to sort out deciduous from evergreen trees, to spot any significant difference in the infrared radiation of ground objects.

Perhaps the complexity of color processing has kept you from exploring this new and profitable field. Don't let it. You are the expert in aerial photography; we are experts in color

processing. We have a complete Aerial Color Film Processing Division set up to handle all your color processing needs . . . infrared or natural color. We can deliver uniform, quality processing . . . roll to roll and week after week.

Spend your efforts where it's profitable for you . . . flying. Let us take over all of your processing worries. Take advantage of our custom service.

Call or Write

Aerial Division
COLOR TECHNIQUE, INC.

Area Code 312 337-5051
100 East Ohio Street, Chicago, Illinois 60611 U.S.A.



COLOR FILM PROCESSING • EKTACOLOR PRINTS • COLOR GLASS DIAPOSITIVES • COLOR ENLARGEMENTS

COLOR TECHNIQUE, Inc.

Welcomes You to the World of Color Aerial Photography...

The acceptance and expanded use of color aerial film over the past 10 years has brought about many technological changes in the science of taking aerial photographs and in the film being manufactured. Keeping abreast of these changes is, to say the least, difficult, especially for anyone outside the laboratory field of operations.

During these dynamic 10 years, the word "service" at Color Technique, Inc.'s aerial division has taken on double meaning. To serve the needs of the aerial photography community we offer:

1. the best and most complete photographic laboratory service anywhere, and,
2. assistance in any way we can towards the successful use of color photographic materials to those who find it necessary to process their own color film due to critical time schedules.

Toward this extra "service" that we have happily made a part of an organization we offer this important and helpful information on the use of color photographic materials for aerial photography.

WHY USE COLOR AERIAL FILM?

The first and most obvious answer to this question is that color film reveals more information than black-and-white film. For example, the greens of nature, deep in tone, as in trees, often reproduce with the same shades of grey when photographed in black-and-white. Color film will easily differentiate more distinctly these hues of green, as it will the hues of all the colors.

Practical Considerations in the Use of Aerial Color Film

Here are 5 important points to remember when planning a mission using color aerial film.

1. All color film should be refrigerated at temperatures below 50 F -- preferably in freezer storage 0 to -10 F. For use, bring the film to room temperature 24 hours before breaking seal of can. (Note: If after the film is at room temperature, flight plans change, it is perfectly all right to return the film to freezer storage so long as seal has not been broken.) Never permit color film to remain in warm areas for any great length of time as deterioration will take place and result in loss of speed and color variations.
2. Accurate exposures should follow. If in doubt, it is best to slightly *overexpose Negative* film and slightly *underexposed Reversal* or Positive Color Film. With Kodak films the use of the Kodak Aerial Exposure Computer is valuable.
3. Use a *Neutral* Anti-vignetting filter, preferably with lenses of short focal lengths, to avoid fall-off in the outer edges of each frame. This area becomes discolored when Color Film is processed.
4. When sending film to Color Technique, Inc. for processing, place the spool of film back in the *original* can and seal the cap. If the original can is not available, be sure to record the emulsion number. This can be found on the manufacturers label. Changes in chemistry and processing times may be required for specific emulsions of film and the lab *must* have this data to give you the best results possible. Use the address label we furnish and ship via *AIR*.
5. Flight data is often helpful to the processing laboratory, especially when reproducing Color Prints. Altitude, time of flight, atmospheric conditions all lend some guidance for reaching proper color balance in prints.

This differentiation of shades of color make it possible for more complete and easier interpretation and extraction of the important data recorded on the film. With color, a geologist has revealed to him substantial differences of the nature of the ground, making for more accurate analysis of mineral content, soil conditions, etc. Highway engineers can plan better roads more rapidly and with greater efficiency using the increased amount of data available in a color aerial photograph. Ground clearance and proper roadbeds can be anticipated more quickly. And, there is some promise that color will help reveal possible landslide areas in mountainous regions.

The benefits made to the aerial photographer by the advent of color films with high degrees of sensitivity (speed), good color fidelity, and almost unlimited versatility are countless. How you can use color aerial films is only limited by your imagination.

HOWEVER, IT IS NOT ALL ROSY-- OR IS IT

The availability of color aerial films that have expanded the science of aerial photography and photogrammetry, also have brought about a new sense of responsibility for the aerial photographer and processing lab technician. More vigilance and knowledge is required than we've been accustomed to in the past.

Color films have at least three gelatin layers, each recording a respective band of the spectrum. It is a complex material requiring new formulae in silver emulsions, dye forming agents, and control balance in the three recording layers.

Such a material is a perishable product. Controlled storage conditions are mandatory. More accurate exposures must be calculated. Processing is advisable within 48 hours after exposure. And, the use of *controlled* chemistry, including accurate time and temperature procedures is a must.

A lot of extra work. A lot of extra trouble. Yes. But for those who have already experienced the added dimensions of color, the work and trouble are more than justified. And, the results more than confirm the extreme value of color.

NEW COLOR AERIAL FILMS ARE AS VERSATILE AS YOU WANT TO MAKE THEM

When Eastman Kodak Company introduced the AERO-NEG System, completely new horizons opened up. The heart of the AERO-NEG System is KODAK EKTACHROME MS AEROGRAPHIC Film, 2448 (ESTAR Base). Although this film is more commonly known as a reversal color film that can be processed to a positive transparency, it also can be processed to a negative without loss of quality. From here, it is possible to proceed in any number of directions, choosing the one that serves you best. For example, the color negative can be used for subsequent direct reproductions as follows:

- Color prints on a paper base
- Positive color transparencies
- Glass diapositives in color

And, they're all in high quality

If black-and-white reproductions are also desirable the same color negative can be used to make:

- Black-and-white prints on a paper base
- Glass diapositives in black-and-white
- Duplicate black-and-white negatives or positives

And again, all in highest quality.

The possibilities made available by color aerial films are unlimited. They will continue to expand. As will the technology of processing and printing these films. The aerial division at Color Technique, Inc. operates as a separate department so that we are able to keep as current as possible on their advancements. It is through our desire to provide you with only the best in service, that we cordially invite you to discuss with us your next color aerial film mission, whether you want us to process the film or if you plan to process it yourself. We welcome the chance to exchange ideas. When you call, simply ask for the "Aerial Division."

COLOR TECHNIQUE, Inc.

Area Code 312 337-5051
100 East Ohio Street, Chicago, Illinois 60611 U.S.A.

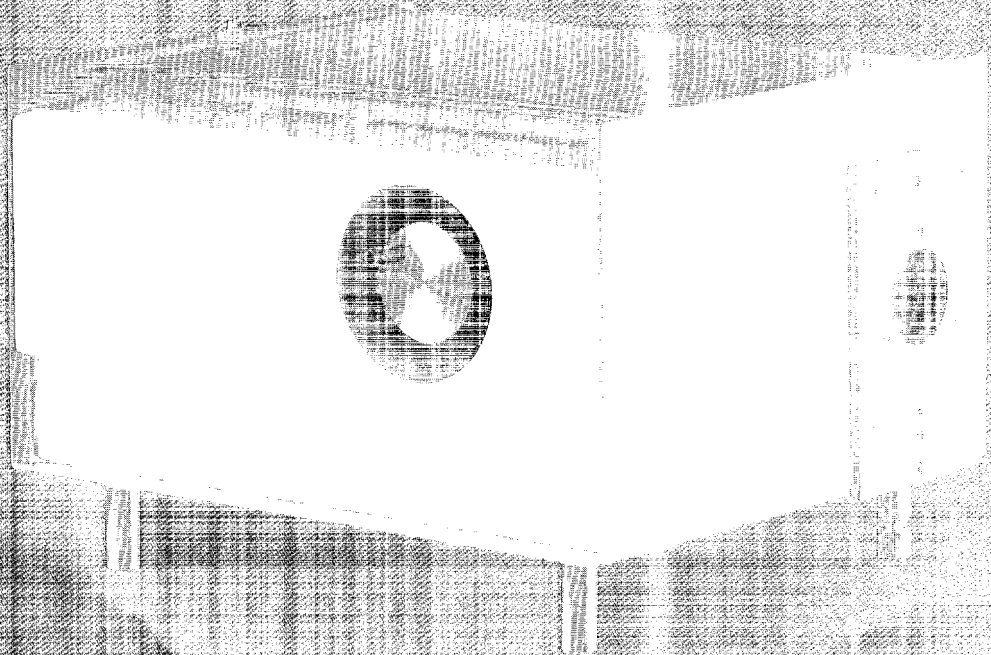


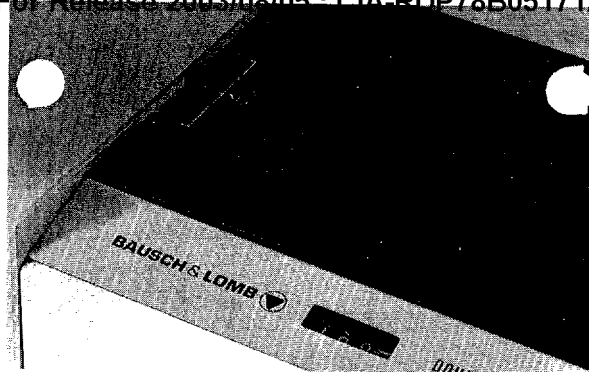
COLOR FILM PROCESSING • EKTACOLOR PRINTS • COLOR GLASS DIAPOSITIVES • COLOR ENLARGEMENTS

double grating monochromator



double grating monochromator





A single lever selects both entrance and exit slits simultaneously.

top efficiency and versatility

This new addition to the Bausch & Lomb line of monochromators provides many of the advantages of a double monochromator at a fraction of the cost. Two Certified-Precision gratings are incorporated in a compact unit, assuring high dispersion in a short path length and reducing stray light to a minimum.

The design of the instrument permits ready incorporation into virtually any system the user wishes to construct. Seven light sources and a wide selection of lenses and other accessories are available for quick attachment, to make this instrument the most versatile monochromator obtainable.

Identical mounting plates on both left and right sides and a reversible optical system permit interchangeable use of the entrance and exit positions. Light sources and accessories can be mounted on either side.

Wavelength range is 190nm-825nm and can be extended to 180nm by purging with dry nitrogen through the inlet provided at the rear of the instrument. A rotatable knob conveniently located on the front panel permits quick selection of the desired wavelength. The selected wavelength shows through a window in the front bezel plate. The plate is easily removable to permit wavelength calibration to a high degree of accuracy.

quickly selected slit widths

To assure the utmost precision in slit widths, the instrument is provided with three fixed slits—which are chosen to give a band pass of 0.2nm, 0.5nm or 2.0nm.

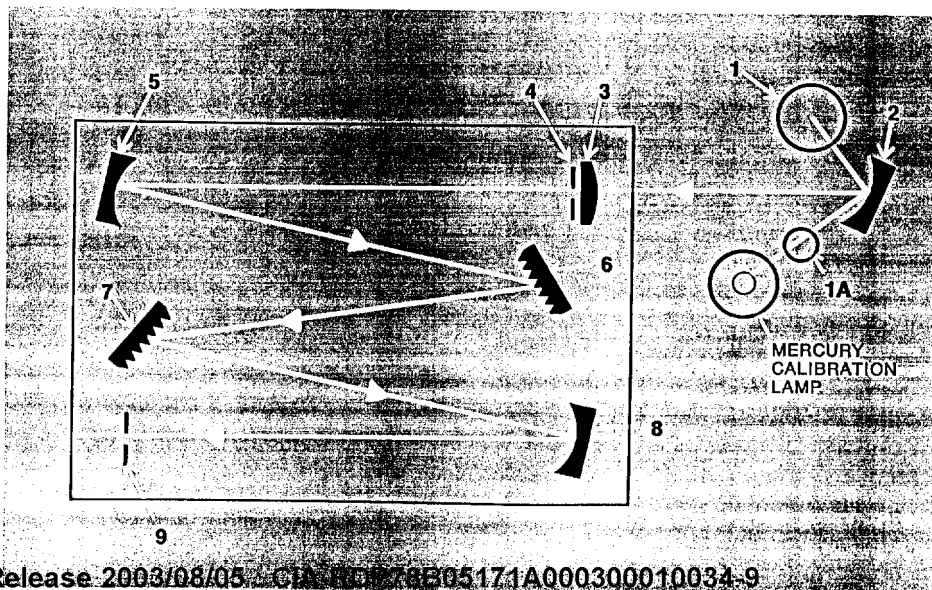
A single lever control selects both entrance and exit slits simultaneously by a ganged mechanism. Slit height is 10mm.

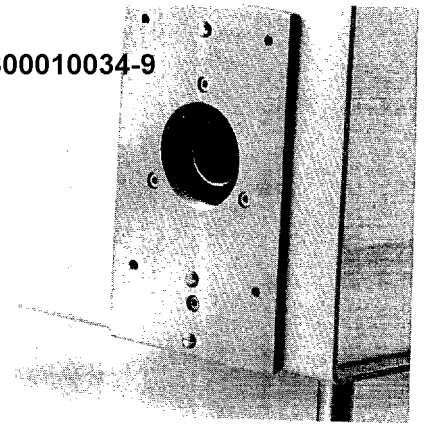
high precision optical system

Two 1200 groove/mm plane reflection gratings are used in a modified Czerny-Turner mount. This provides wide

wavelength coverage and also allows the instrument to be optimized for the 200nm region. Both gratings have a free aperture of 25mm diameter and an efficiency greater than 60% at 253.7nm.

The beam from a light source (1 or 1A) depending on the rotation of the condensing mirror (2) is focused on the entrance slit (4) by the slit collector lens (3). The beam then passes to the collimating mirror (5) and is reflected to the first reflection grating (6), where it is dispersed, then to a second reflection grating (7) where it is further dispersed. The twice dispersed beam is reflected from the second collimating mirror (8) and passes through the exit slit (9).





Mounting plates are identical at entrance and exit positions and the optical system is reversible.

motor drive for wavelength scanning

This is an optional accessory which can be attached to the monochromator without tools simply by depressing a lever. In order to maintain synchronization with the wavelength dials, the spectrum is scanned only from the blue toward the red. Three scanning speeds can be selected; 5, 25, and 125nm/min. In addition to a neutral position, a high speed drive (500nm/min) is available for slueing the monochromator either forward or backward.

7 light sources available

Bausch & Lomb offers an extensive group of light sources for most applications. It is possible to use a presently owned source or to purchase a special source for specific applications. Although sources other than B&L units can be used, the optical system has been designed specifically to match all B&L light sources with the monochromator. Thus for maximum efficiency and optimum performance, the B&L light source is recommended.

If optimum performance is not required other sources may be used. Alternately, optimum performance can be obtained with other sources if a suitable optical system is designed, built, and installed.

1. Xenon Light Source. The emitting element of this lamp is a short electric arc in high pressure xenon contained within an envelope of fused silica. It is a high intensity continuous source which operates at a power level of 150 watts, and 25,000 volts R.F. The R.F. energy is confined to the interior of the

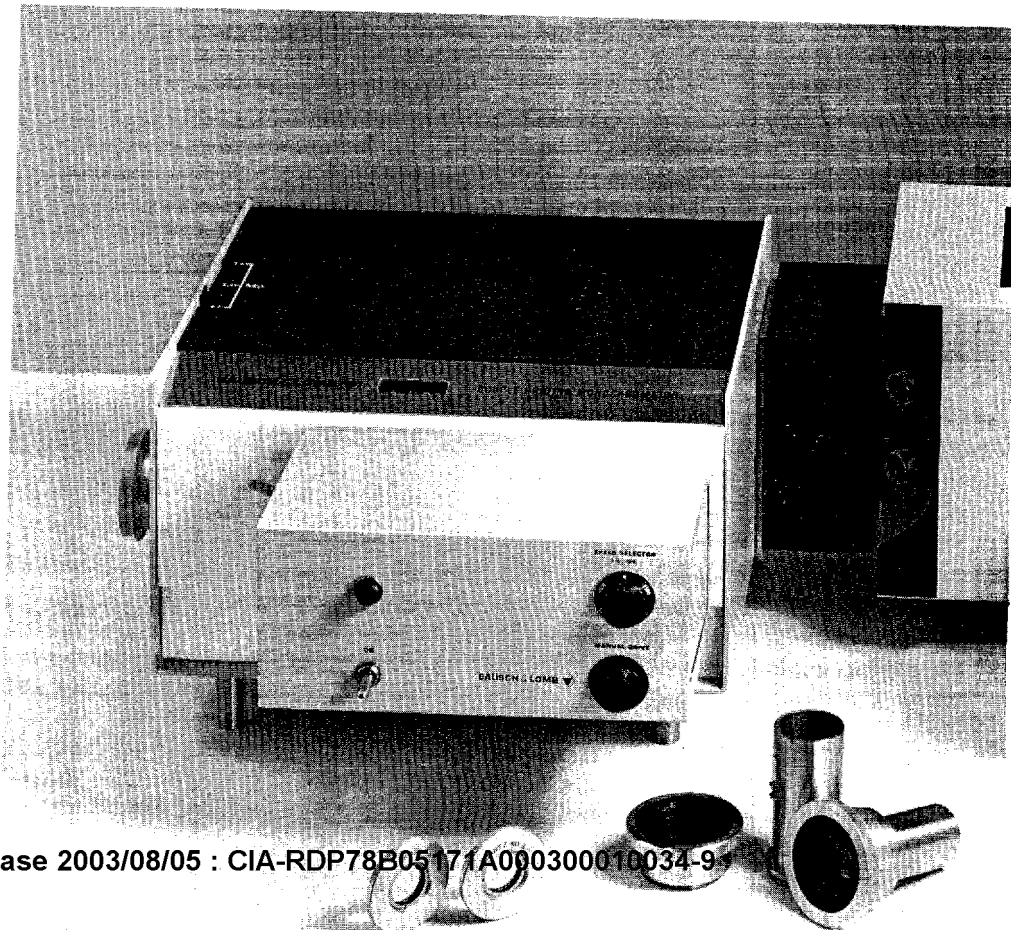
lamp housing thus eliminating hazard to personnel. The lamp envelope transmits from wavelengths shorter than 200nm to wavelengths longer than 3.5 micrometers. In the visible region this lamp has a color temperature of about 5000 Kelvins. Brightness distribution is 96 candles per sq. mm. over an effective area of 0.75mm x 1.50mm. Lamp life is approximately 1000 hours.

The power supply is a separate, compact unit 23cm x 36cm x 19cm—with an on-off switch and pilot lamp.

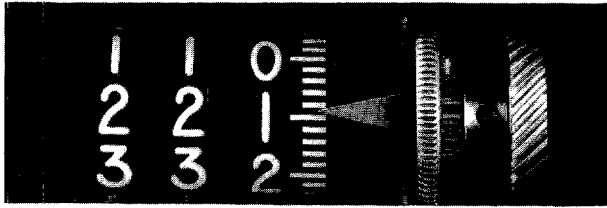
One of the outstanding features of this Xenon source is its high stability. There is none of the flicker that is characteristic of other Xenon sources.

2. Air Cooled Deuterium Arc Source. The emitting element of this lamp is a D.C. arc in Deuterium contained within a fused silica envelope.

The useful spectral range is from 200nm to 400nm only. It is, therefore, strictly an ultraviolet source, and is recommended for work requiring continuous spectral illumination in the UV. The power supply contains a full wave rectifier for converting AC to DC and a special circuit for starting the lamp. Also included in the unit are a meter for current setting, an on-off switch and pilot lamps. In those cases where a highly regulated, well-filtered DC output is required, the Dual Light Source is recommended.



Seven light sources and a wide selection of lenses and filters are available for quick attachment.



Easy access to adjustment ring permits highly accurate wavelength calibration.

3. Super-Pressure Mercury Source.

This is a 200 watt mercury vapor lamp with a fused silica envelope. It is supplied with a fused silica condenser system and an AC power control unit. It is recommended where a very high intensity emission spectrum (line spectrum) is required. However, the very high pressure in the lamp broadens the emission lines appreciably and superimposes a low level continuum upon the line spectrum.

4. High Pressure Mercury Source.

This lamp is similar in most respects to the Super Pressure Mercury Source but operates at 100 watts. It also has a fused silica envelope and condenser

system and an AC power control unit. Because of the lower power level, the pressure in this lamp is less than in the super pressure source. Thus, the pressure-broadening of the lines is less and the continuum is at a lower level.

5. Coil Filament (Tungsten-Halide) Source.

This source is frequently called a quartz-iodine lamp. It is a coiled tungsten filament operating at 6.8 volts and 45 watts. The envelope is made of fused silica and it contains a halogen, usually iodine or bromine, which is found to prolong the lamp life and prevent darkening of the bulb. The source is supplied with a fused silica condenser system. The transformer is an

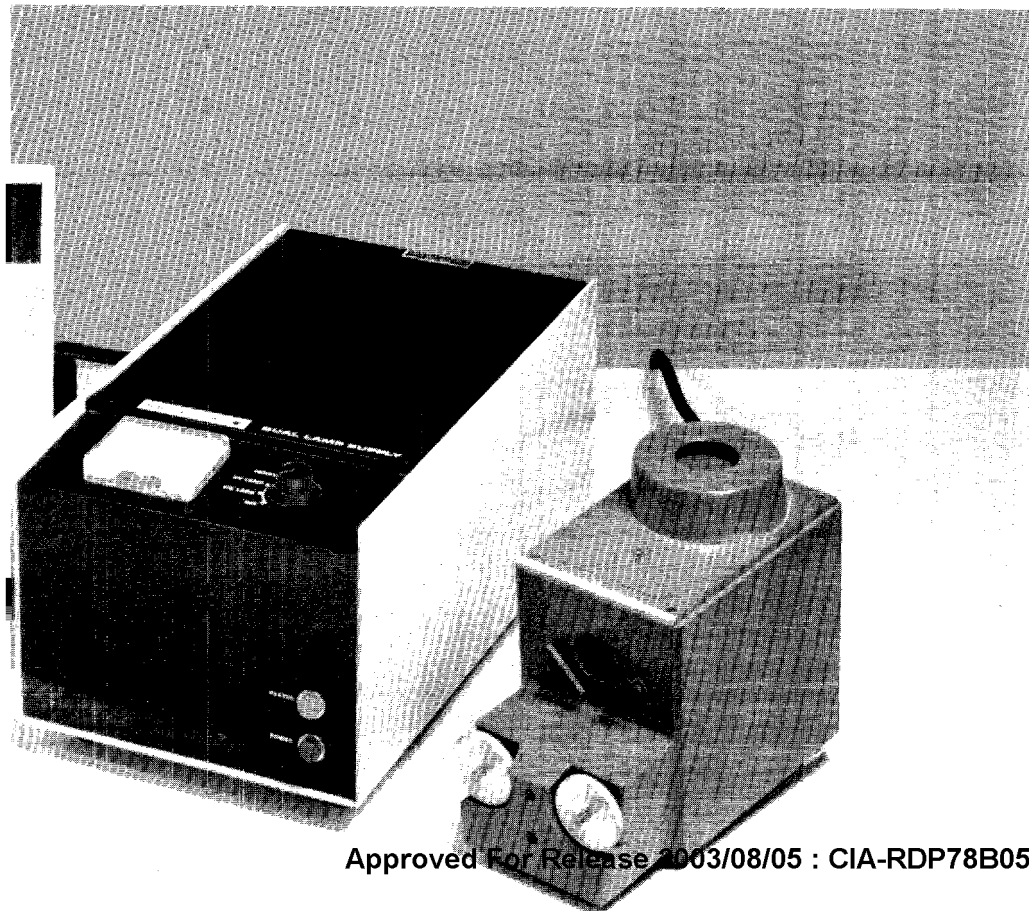
integral part of the lamphouse. It provides a continuous spectrum and is recommended for use in the near UV, visible, and infrared regions.

6. Tungsten Ribbon Filament Source.

This filament operates at 6 volts AC and 18 amperes. It emits a continuous spectrum from 300nm into the far infrared. The transformer is part of the lamphouse. The use of a ribbon filament assures a more uniform, or homogeneous brightness than can be obtained with a coil filament but there is some reduction in output.

7. Dual Light Source.

The Dual Light Source consists of a Deuterium Source, a Tungsten-Halide Source, Power Supply and Adapter Box. The fully transistorized power supply provides a very well regulated current and potential source for the lamps. It is mounted on the lamphouse. The power supply provides a constant current for the Deuterium Lamp with the current regulated to $\pm 0.03\%$ and with a drift of less than 0.5% per hour. Alternately, it will provide a constant potential regulated to $\pm 0.03\%$ with drift of less than 0.1% per hour. The ripple is less than 0.1% r.m.s. The power supply will operate satisfactorily with an input potential of 108 to 128 volts AC and an input frequency from 50 to 60 Hz. The adapter box unit is cast aluminum with a hinged cover. It forms a bridge between the monochromator and the lamphouse and provides the proper optical spacing to match the focal ratio and the focusing requirements. It also serves as a holder for filters and other optical components and provides light shielding. The lamp house has conveniently located controls for centering the lamp with respect to the optical train.



accessories

extendable lens tube

This accessory consists of two aluminum tubes which are threaded on both ends. One tube is approximately twice the length of the other. They are designed primarily for use with the Silica-Fluorite Focusing Lens and work as follows: When the lens is screwed into the short tube it provides a collimated beam; when the two tubes are screwed together it provides a 1:1 slit image; and when it is used with a long tube alone it gives an intermediate image. The tubes can also be used with any of the collector lenses to give a wide variety of imaging options.

silica-fluorite focusing lens

This is a fused Silica—Fluorite triplet installed in a mount. It is achromatized over the 200 to 800nm wavelength range. Optimum performance is achieved when used 1:1 at a focal ratio of $f/10$; however it gives good achromatization for collimation and intermediate imaging positions.

general purpose lenses

No additional lens is essential to the basic operation of the Dual Grating Monochromator. However, when attached to the slit plate at the exit, these lenses provide various sized images of the (circular) aperture. When used in the various lens tubes they provide a (rectangular) image of the exit slit at various locations. There are five lenses to choose from depending upon the application. Four of the lenses are made of fused silica and have focal lengths of 39mm, 66mm, 86mm and 152mm. The fifth lens is a Fluorite-Fused Silica-Fluorite triplet of 197mm focal length.

photomultiplier-phototube housing

This optional Photomultiplier Detector has electrical connections to permit use with conventional High Voltage Power Supplies and Microammeters.

specifications of the double grating monochromator

Mounting: Modified Czerny-Turner, double grating

Reciprocal Linear Dispersion: 1.5nm/mm (approximately constant over entire wavelength range)

Focal Ratio: $f/10$

Focal Length: 250mm

Wavelength Readout: Digital Counter

Wavelength Range: 190* to 825nm.

*The UV wavelength range can be extended to 180nm by purging with dry nitrogen.

Wavelength Accuracy: Can be set to better than ± 1 nm using wavelength calibration sources.

Gratings: Two gratings in tandem with:

- Efficiency—greater than 60% at 253.7nm
- Grooves/mm—1200
- Free Aperture—25mm diameter
- Blaze—broad blaze for wide wavelength coverage, optimized for 200nm region

Slits: Fixed variable type providing: 0.2, 0.5, and 2.0nm bandpass (Note: 0.2nm slits are curved). Slits are mechanically coupled with a single de-tented lever control. Slit height is 10mm.

Stray Light: Less than .001% at 313nm, and Less than .01% at 254nm using a high pressure mercury source.

SIZE AND MASS

Length—33cm (13 inches)
Width—27cm (10¾ inches)
Height—23cm (9 inches)
Mass—10.5 kg (weight 23 lbs.)

ORDERING INFORMATION

Cat. No.	Description
33-86-66	Double Grating Monochromator

LIGHT SOURCES

33-86-20	Xenon Light Source and Power Supply
33-86-35	Deuterium Light Source and Power Supply
33-86-36	Super Pressure Mercury Source and Power Supply
33-86-38	High Pressure Mercury Source and Power Supply
33-86-39	Tungsten-Halide Source
33-86-59	Tungsten Ribbon Filament Source
33-86-68	Dual Lamphouse—with Deuterium Source, Tungsten-Halide Source, Mercury Calibration Source, Dual Lamp Supply and Adapter Box

GENERAL PURPOSE LENSES

33-86-29	Silica 39mm focal length
33-86-72	Silica 66mm focal length
33-86-34	Silica 86mm focal length
33-86-63	Silica 152mm focal length
33-86-69	Fluorite-Silica-Fluorite, 197mm focal length

OTHER ACCESSORIES

33-86-70	Extendable Lens Tube
33-86-67	Wavelength Motor Drive Phototube and Photomultiplier Housing

REPLACEMENT LAMPS

33-33-02	Super Pressure Mercury Lamp (SP-200) 200W
33-33-09	Tungsten Lamp
33-33-15	Tungsten-Halide Lamp, 45W
33-33-30	Deuterium Lamp, 20W
33-33-38	Tungsten Lamp 6V. 18 amp.
33-33-42	High Pressure Mercury Lamp (HP-100) 100W
33-33-20	Xenon Lamp, 150W

DOUBLE GRATING MONOCHROMATOR

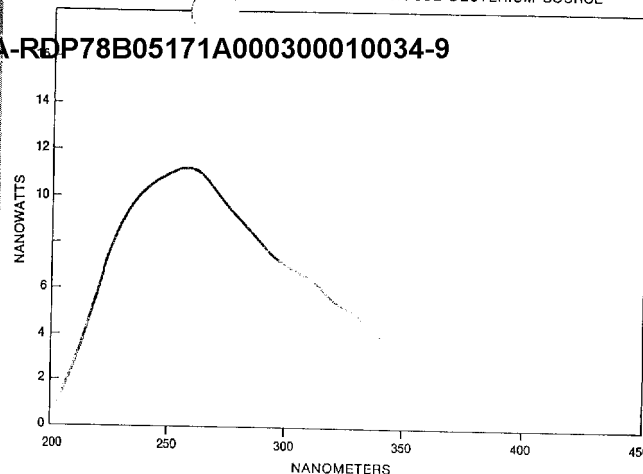
CATALOG NUMBER	DESCRIPTION	SUGGESTED LIST PRICE	CATALOG NUMBER	DESCRIPTION	SUGGESTED LIST PRICE
33-86-66-01	Double Grating Monochromator	\$1,290.00	ACCESSORY LENSES		
33-86-70	Telescoping Lens Tube	85.00	33-86-69	Lens	\$195.00
33-86-67	Wavelength Drive 60 Hz 115 V	395.00	33-86-72	Lens	48.00
LIGHT SOURCES			33-86-29	Lens	35.00
33-86-68-01	Dual Lamphouse (UV-VIS) Power Supply & Adapter	1,245.00	33-86-34	Lens	35.00
33-86-20	Xenon Light Source & Power Supply	900.00	33-86-63	Lens	35.00
33-86-35	Deuterium Light Source & Power Supply	690.00	REPLACEMENT LAMPS		
33-86-36	Super Pressure Mercury Source & Power Supply	600.00	33-33-02	Super Pressure Mercury Lamp (SP-200) 200 watts for 33-86-36-01 Light Source	45.00 M.C.P.
33-86-38	High Pressure Mercury Source & Power Supply	600.00	33-33-15	Tungsten-Halide Lamp, 45w for 33-86-39-01 Light Source	9.15 M.C.P.
33-86-39	Tungsten-Halide Source & Power Supply	290.00	33-33-20	Xenon Lamp, 150 watts for 33-86-20-01 Light Source	85.00 M.C.P.
33-86-59	Tungsten Ribbon Filament Source & Power Supply	280.00	33-33-30	Deuterium Lamp, 20 watts for 33-86-35-01	120.00 M.C.P.
			33-33-38	Tungsten Lamp, 6 volts, 18 amps. for 33-86-44-01 and 33-86-59 Light Source	11.00 M.C.P.
			33-33-42	High Pressure Mercury Lamp (HP-100) 100 watts for 33-86-38-01	65.00 M.C.P.

Prices are subject to change without notice. Excise taxes or other governmental charges will be added wherever applicable.

BAUSCH & LOMB  ROCHESTER, NEW YORK
ANALYTICAL SYSTEMS DIVISION

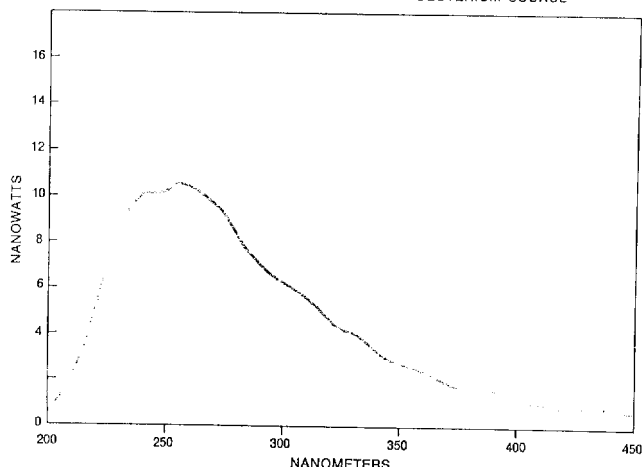
typical total radiant flux
as a function of wavelength
using various light sources

TYPICAL RADIANT FLUX—DUAL LAMP HOUSE DEUTERIUM SOURCE



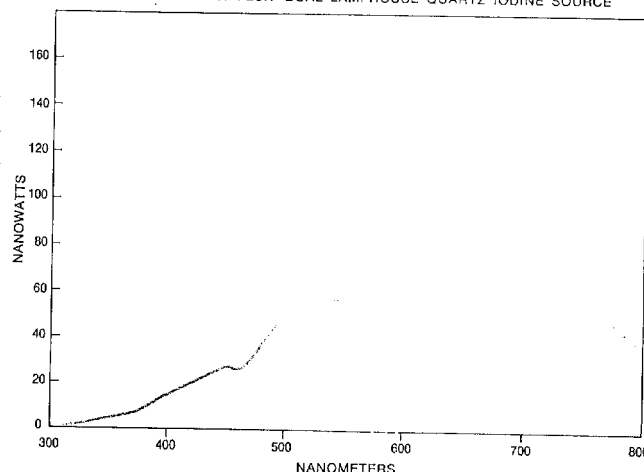
MONOCHROMATOR: B&L Cat. #33-86-66
SOURCE: B&L Cat. #33-86-68 Deuterium, 0.8amp, 60 VDC
BANDPASS: 5 Å
FILTERS used to eliminate higher order Spectra (curve corrected for filter absorption): None, Range 200-400nm, Corning HO-52, Range 400-450nm

TYPICAL RADIANT FLUX—HI INTENSITY DEUTERIUM SOURCE



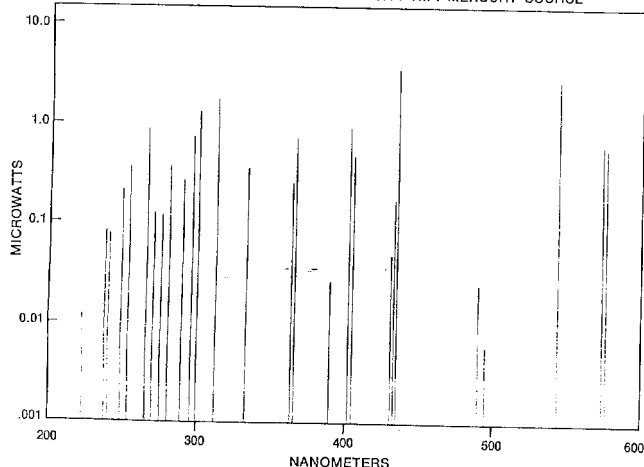
MONOCHROMATOR: B&L Cat. #33-86-66
SOURCE: B&L Cat. #33-86-35-01 Deuterium, 0.8amp, 60vac, full-wave Rectified
BANDPASS: 5 Å
FILTER, used to eliminate higher order spectra (curve corrected for filter absorption): None, range 200-400nm, Corning HO 52, range 400-450nm

TYPICAL RADIANT FLUX—DUAL LAMPHOUSE QUARTZ IODINE SOURCE



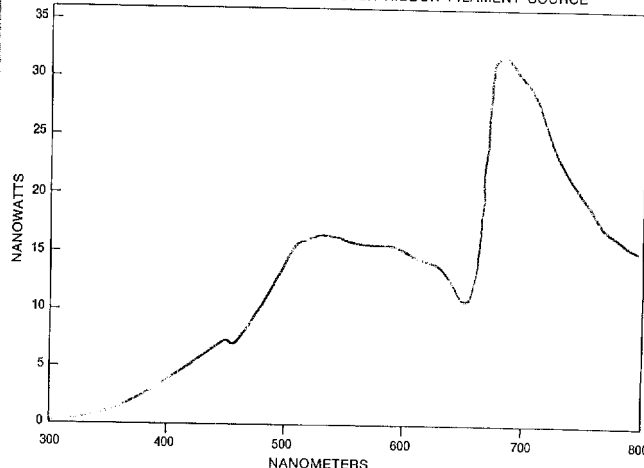
MONOCHROMATOR: B&L Cat. #33-86-66
SOURCE: B&L Cat. #33-86-68 Tungsten (Quartz-Iodine) 0.8amp, 60 VDC
BANDPASS: 5 Å
FILTERS used to eliminate higher order Spectra (curves corrected for filter absorption): None, 300-710nm, Corning H2-58, 710-800nm

TYPICAL RADIANT FLUX—HI INTENSITY H.P. MERCURY SOURCE



MONOCHROMATOR: B&L Cat. #33-86-66
SOURCE: B&L #33-86-42-01 High Pressure Mercury HP-100
BANDPASS: 5 Å
FILTER used to eliminate higher order spectra: None

TYPICAL RADIANT FLUX—TUNGSTEN RIBBON FILAMENT SOURCE



MONOCHROMATOR: B&L Cat. #33-86-66
SOURCE: B&L Cat. #33-86-44-01, Tungsten Ribbon Filament, 18amp, 6 VAC
BANDPASS: 5 Å
FILTERS used to eliminate higher order Spectra (curves corrected for filter absorption): None, 300-710nm, Corning H2-58, 710-800nm

ROCHESTER HEADQUARTERS

Bausch & Lomb, Inc.
Analytical Systems Division
820 Linden Avenue
Rochester, N.Y. 14625
(716) 385-1000

NEW YORK-NEW JERSEY

Bausch & Lomb, Inc.
Analytical Systems Division
Room 404
100 Menlo Park
Edison, New Jersey 08817
(201) 548-9411

BOSTON

Bausch & Lomb, Inc.
Analytical Systems Division
565 Commonwealth Avenue
Boston, Massachusetts 02215
(617) 262-6100

WASHINGTON

Bausch & Lomb, Inc.
Analytical Systems Division
Suite 304, Executive Building
7100 Baltimore Avenue
College Park, Maryland 20740
(301) 779-1230

PHILADELPHIA

Bausch & Lomb, Inc.
Analytical Systems Division
349 Lancaster Avenue
Haverford, Pennsylvania 19041
(215) MI 9-6663

HOUSTON

Bausch & Lomb, Inc.
Analytical Systems Division
Suite 240
6400 West Park Drive
West Park Plaza
Houston, Texas 77027
(713) 781-0276

ATLANTA

Bausch & Lomb, Inc.
Analytical Systems Division
3355 Lenox Road N.E.
Suite 860
Atlanta, Georgia 30326
(404) 261-5021

CHICAGO

Bausch & Lomb, Inc.
Analytical Systems Division
899 Skokie Boulevard
Northbrook, Illinois 60062
(312) 498-0400

DETROIT

Bausch & Lomb, Inc.
Analytical Systems Division
20200 W. Outer Drive
Dearborn, Michigan 48124
(313) 565-6628

SAN FRANCISCO

Bausch & Lomb, Inc.
Analytical Systems Division
780 West Grand Avenue
Oakland, California 94612
(415) 836-2366

LOS ANGELES

Bausch & Lomb, Inc.
Analytical Systems Division
17452 Irvine Boulevard
Tustin, California 92680
(714) 544-0830

TORONTO

Bausch & Lomb-Canada
Analytical Systems Division
1790 Birchmont Road
Scarborough, Ontario
(416) 291-7911

MONTREAL, P.Q.

Bausch & Lomb-Canada
Analytical Systems Division
110 Cremazie West, Suite 707
Montreal 11, Quebec
(514) 381-8519

OTTAWA

Bausch & Lomb-Canada
Analytical Systems Division
227 Laurier Ave. West
Ottawa, Ontario
(613) 232-1544

BAUSCH & LOMB  ROCHESTER, NEW YORK 14625
ANALYTICAL SYSTEMS DIVISION

International Office

Analytical Systems Division products
are available in most countries.

For information, write:

Bausch & Lomb, Inc.
Analytical Systems Division
International Marketing
820 Linden Avenue
Rochester, N.Y. 14625

PRECISION SPECTROPHOTOMETER



Approved For Release 2003/08/05 : CIA-RDP78B05171A000300010034-9
SINGLE BEAM • DOUBLE-GRATING • WAVELENGTH RANGE—190-800mμ • UNPARALLELED PRECISION • RELIABILITY • EASE OF USE

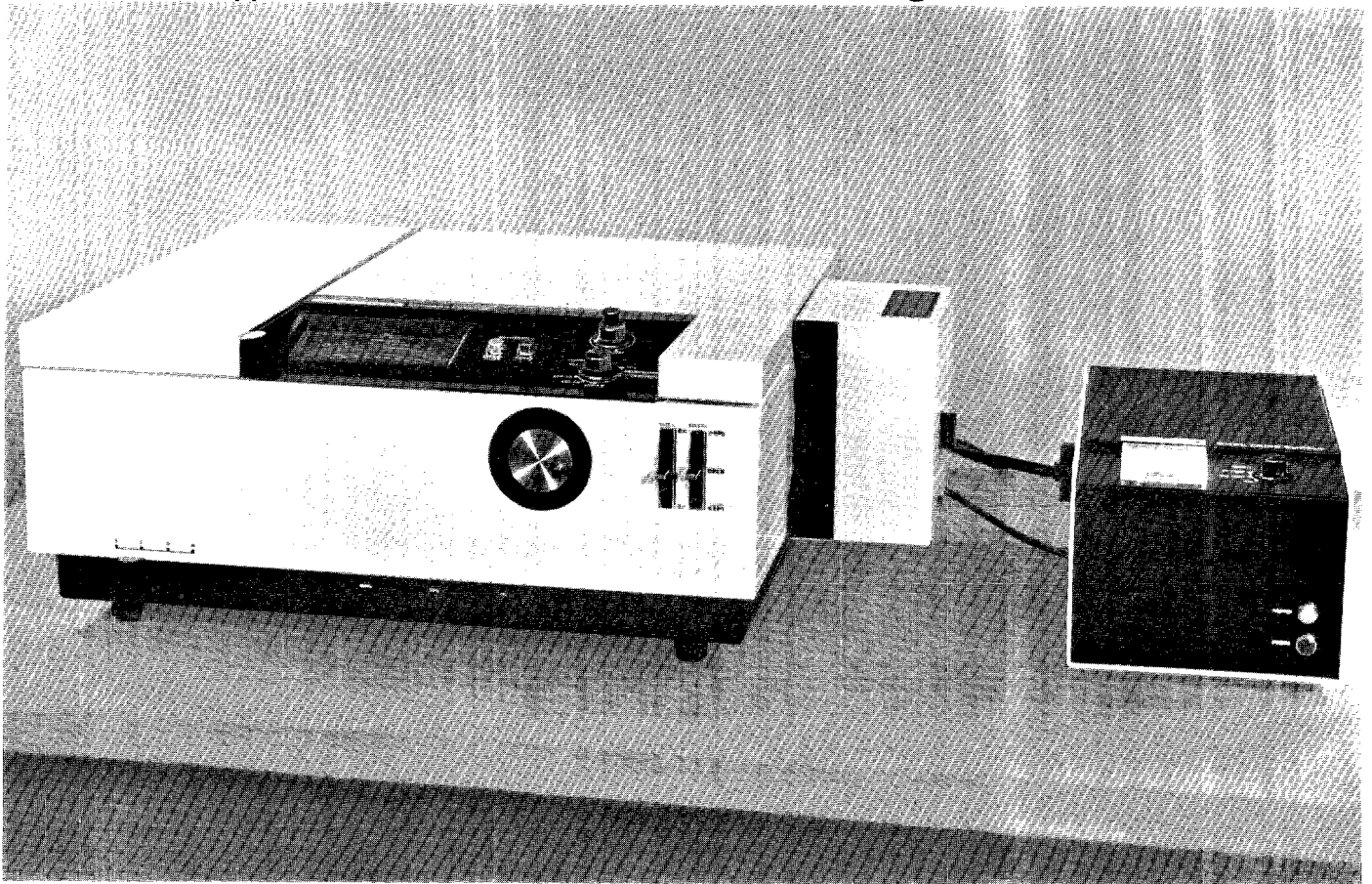
COMBINES PRECISION PERFORMANCE WITH EASE AND SPEED OF OPERATION

Spectrophotometric determinations requiring the highest precision can be routinely performed with this newest addition to the Bausch & Lomb line of Spectrophotometers. Every component used in the instrument has been carefully selected to insure that the system will provide optimum stability and precision. A superior lamp supply, photomultiplier supply and amplifier further guarantee top reliability.

In addition to high precision and reliability, the instrument has built into it many features that insure ease, speed and convenience of operation for the user.

DESIGNED FOR EASY ACCEPTANCE OF ACCESSORIES

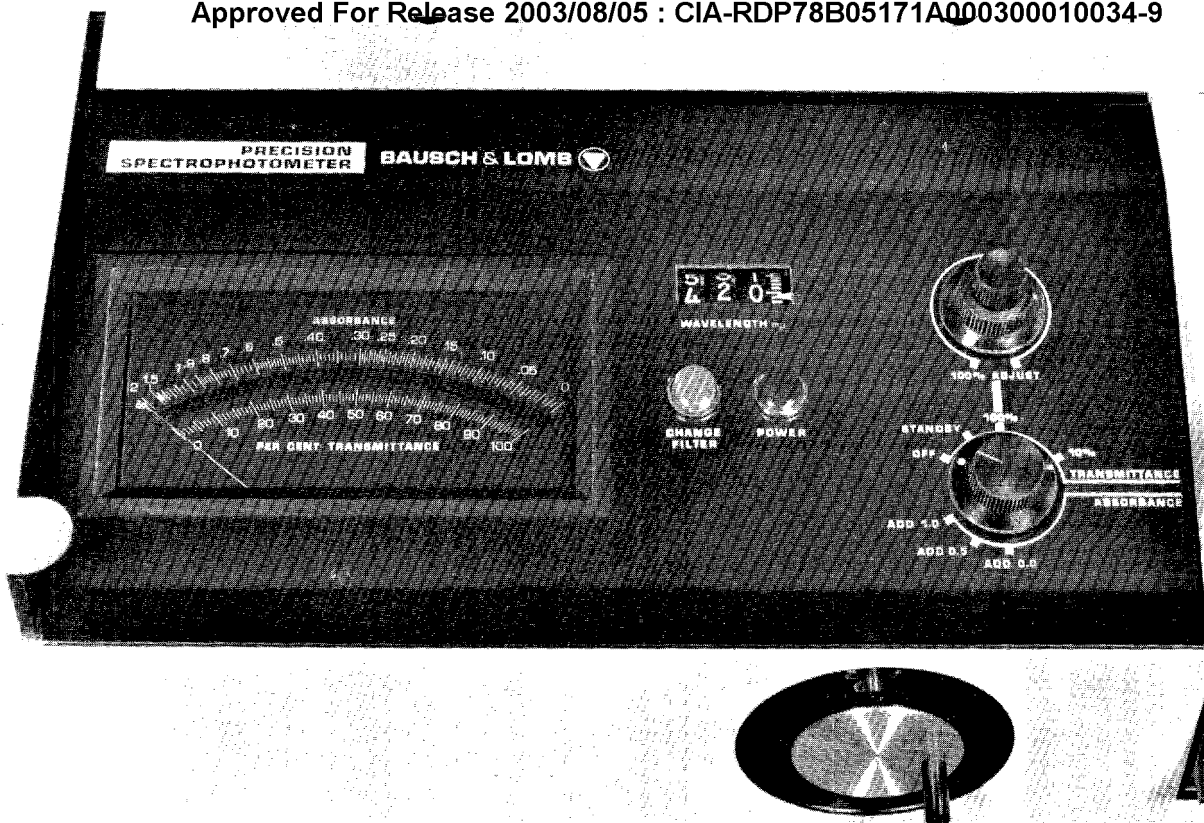
Inherent in the design of the Precision Spectrophotometer is the ability to accept a variety of available accessories without special adaptation. Use of these accessories and future accessories was planned for on the instrument blueprints. Adding to the instrument's versatility are a huge sample compartment which permits extremely high flexibility in sample size and shape, easily interchangeable optical systems, and selection of a variety of readout devices.



OCCUPIES SMALL BENCH AREA

The Precision Spectrophotometer and Dual Power Supply occupy little bench space. Actual area required measures about 23" x 37". Smooth, baked enamel finish assures easy cleaning and high resistance to scratching, chipping and reagent stains. Color is off-white with black markings, making it an extremely attractive instrument in any lab.

PRECISION SPECTROPHOTOMETER



FAST, CONVENIENT OPERATION

The instrument meter and operating controls are mounted on a tilted panel directly in front of the user. Meter markings are high contrast white on black. All markings and the dial pointer show up sharply, distinctly, considerably reducing the possibility of error in transcribing readings. Graduations are in Percent Transmittance and Absorbance. The photometric range switch turns the instrument on causing a red light to glow on the instrument panel. The range switch also permits selection

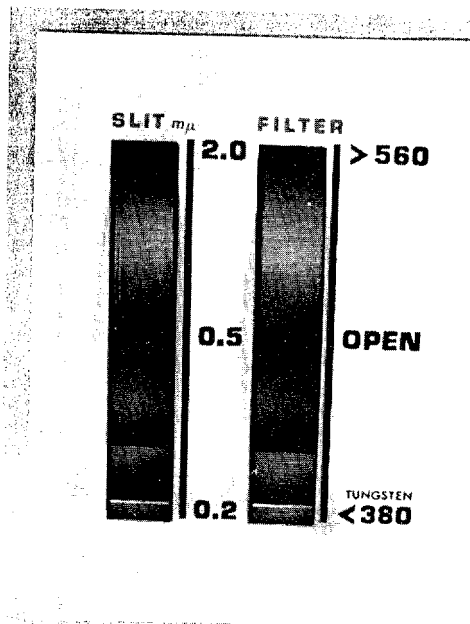
of any one of 5 photometric ranges—10% and 100% transmittance and 0.0-2.0, 0.5-2.5, 1.0-3.0 absorbance, all full scale values.

The "100% Adjust" control, immediately above the range switch, sets the dial pointer (or the indicator of accessory readouts) to a selected reference value, for transmittance or absorbance measurements. Normally, this will be 100% for transmittance, zero for absorbance.

A rotatable knob on the front face of the instrument permits rapid setting of the wavelength counter to the desired wavelength. Graduations are to .2 mμ but the counter can easily be set to .1 mμ.

An amber warning light designated "CHANGE FILTER" lights up when the filter in the optical path is the wrong one for the wavelength and source parameters selected. The simple flick of a detented lever immediately brings the proper filter into position.

PRECISION SPECTROPHOTOMETER

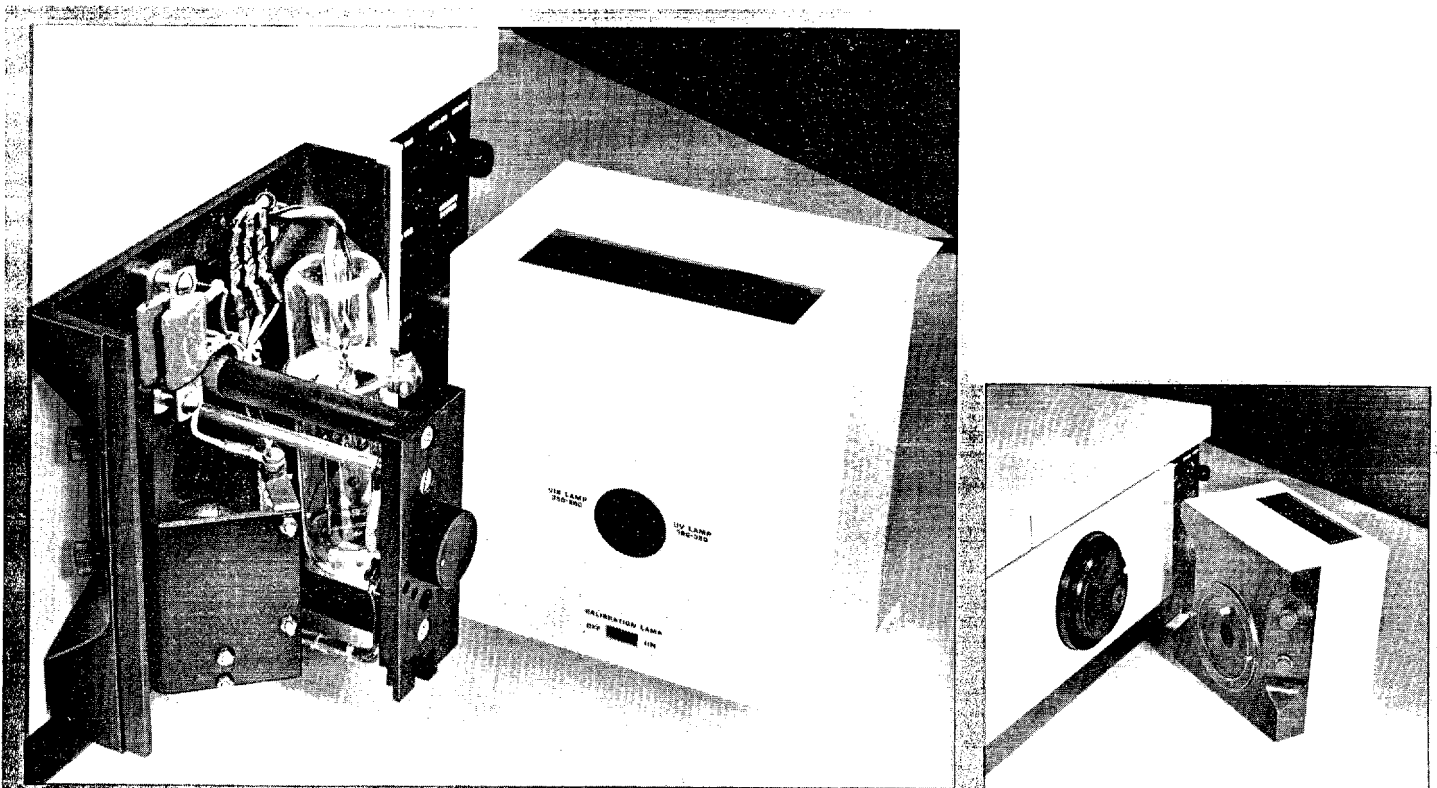


BUILT-IN FILTERS SELECTED BY THE FLICK OF A LEVER

To eliminate the annoyance of having to manually position filters in the optical path, a 2nd order filter and a stray light filter are built into the Precision Spectrophotometer. A detented lever permits instant selection of the 2nd order filter for work above 560 $m\mu$ and a stray light filter when working in the UV (below 380 $m\mu$ with the quartz iodine lamp. With the lever in the "open" position neither filter is operable.

CONSTANT BANDPASS OVER ENTIRE RANGE

The bandpass (resolution) is constant over the entire wavelength range. Three separate sets of slits are built-in and are selected simply by moving a lever to the desired slit width. Slit widths are 0.2, 0.5 or 2.0 millimicrons.

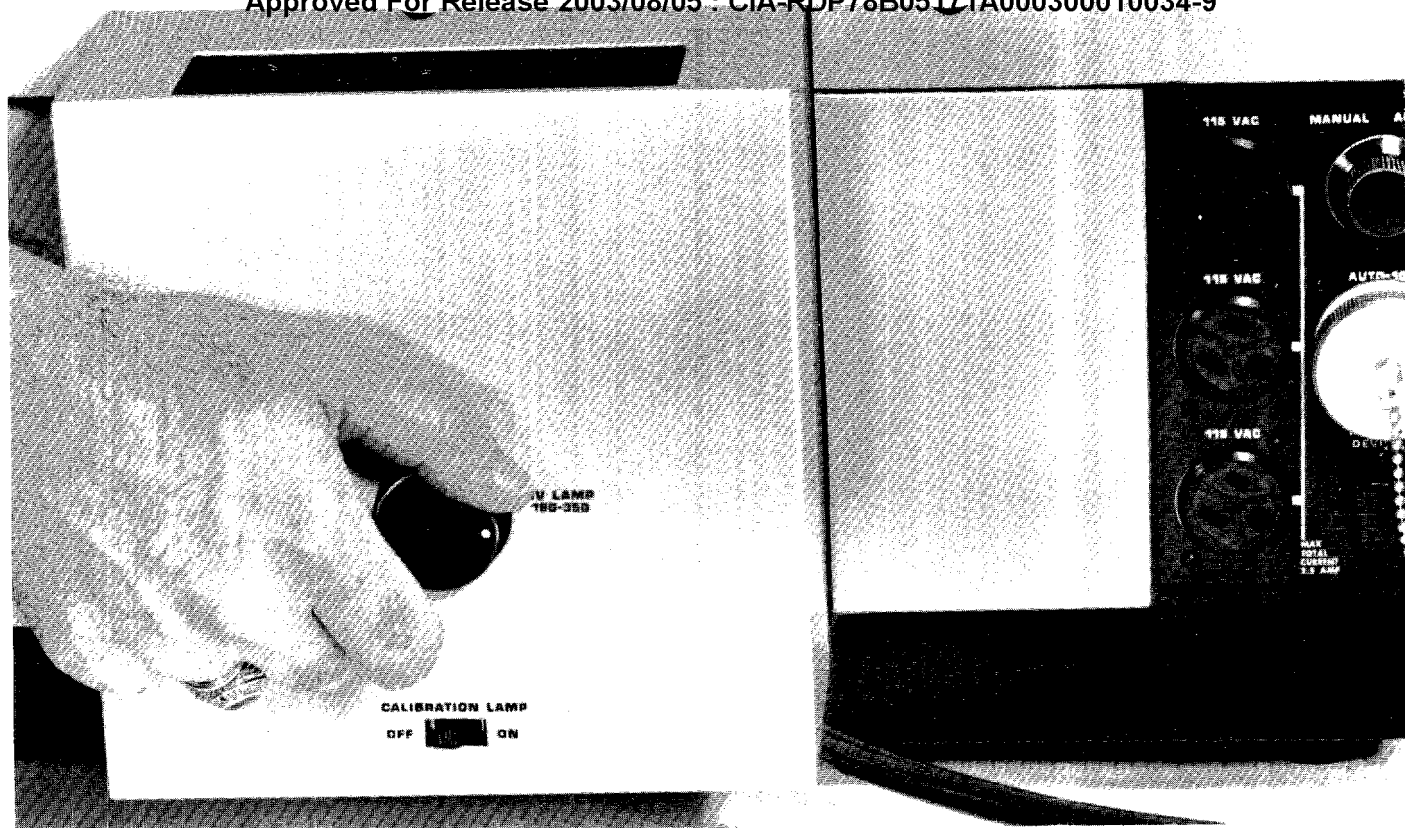


The simplicity of adjustment for centering the lamps is ingenious. Two knurled knobs are provided on the side of the lamp casting. Centering procedure is to turn the top knob until the meter peaks, then turn the lower knob until the meter peaks. This precisely centers the lamps.

The entire lamphouse can be removed by turning a single screw. A carefully machined mounting ring

and two precise locating pins assure accurate repositioning of the lamphouse as well as accurate interchangeability with other entrance accessories. An adaptor flange with a quartz-condensing system can be mounted in place of the lamphouse to accept the emission accessories available for use with this instrument.

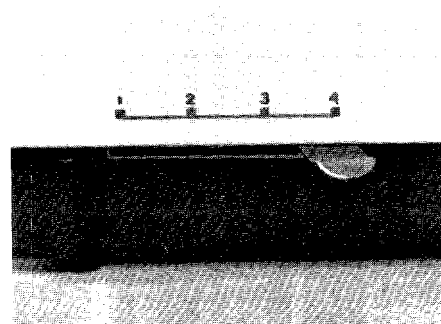
The lamphouse cover can be removed in a matter of seconds to permit simple, fast replacement of lamps. The deuterium lamp is a special pre-focused lamp with a large 2.5mm arc which permits filling of the slit. It has a rated life of 500 hours. The quartz-iodine lamp has a 1000 hour life and can be used to below 260 mμ, easing the load on the shorter-lived deuterium lamp. Stray light at this wavelength is less than 1/2 %.



FINGERTIP SELECTION OF DEUTERIUM, TUNGSTEN OR MERCURY CALIBRATION LAMP

Two light sources are built into the Precision Spectrophotometer; a deuterium lamp and a quartz-iodine lamp. A mercury calibration lamp is also provided. A knob protruding through the source cover permits convenient selection of either the

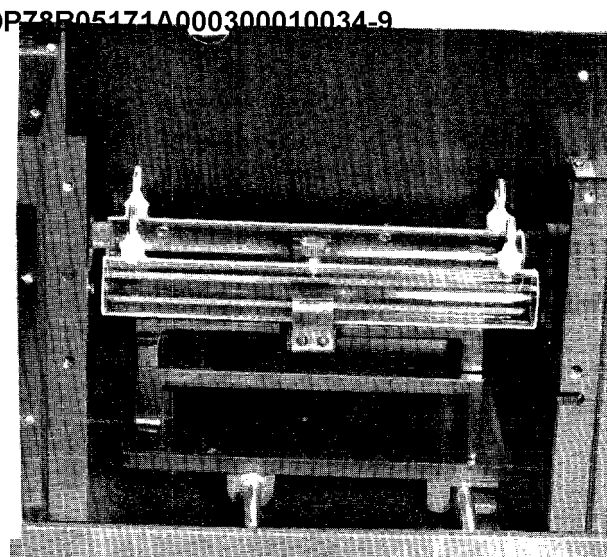
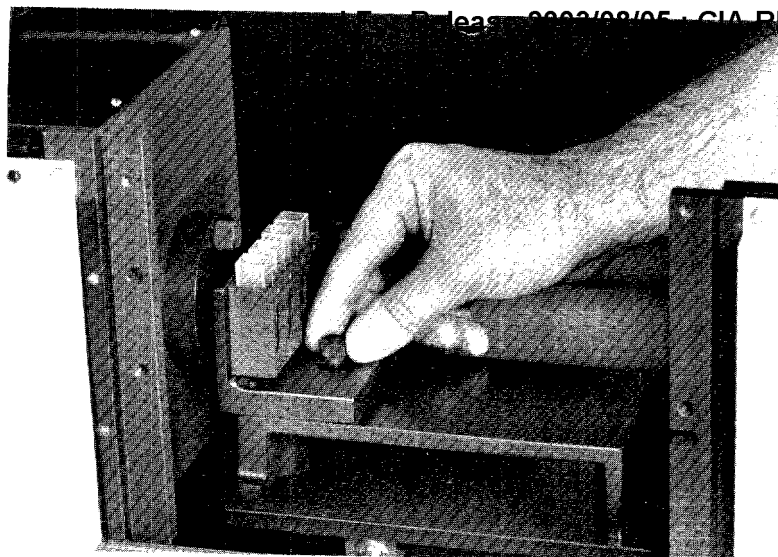
visible lamp or the UV lamp. A small switch below the selector knob turns off the visible or UV lamp and ignites the mercury calibration source, which can be used at any time for a wavelength check.



FAST, ACCURATE READINGS

The sample selector lever actuates a movable stage within the sample compartment. Each of the 4 positions is firmly detented to assure precise positioning of each sample in the optical path.

PRECISION SPECTROPHOTOMETER



EXTREMELY LARGE AND VERSATILE SAMPLE COMPARTMENT

The sample compartment measures 6" x 6" x 8 $\frac{1}{16}$ ". This wealth of space permits use of large samples, special accessories and complete versatility in sample handling techniques. A number of accessories are available, a few of which are shown on these 2

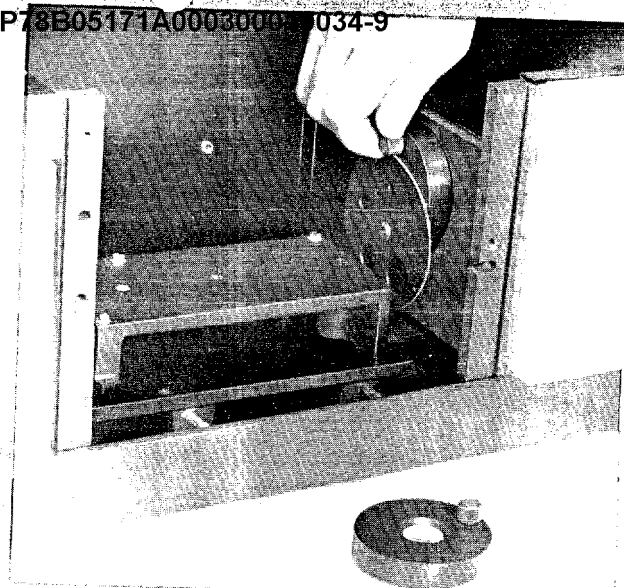
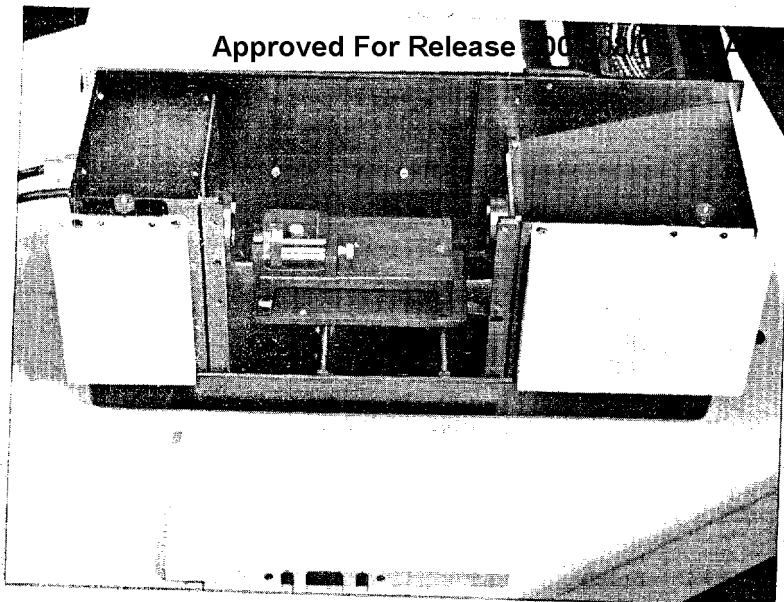
pages. The side panel has been removed in 4 of the photos for purposes of illustration.

The standard sample holder accommodates four 10mm square cuvettes. The holder will also handle micro-cell or a flow-thru cell. Accessory units can be substituted for the 4 cell holder simply by loosening a knurled thumb screw. A slot and pin

arrangement assures quick, positive positioning of the various sample holders available.

The cylindrical cell holder, is shown above with two 27mm x 200 mm silica cells. Cell lengths of 10, 25, 50 and 100mm are also available.

PRECISION SPECTROPHOTOMETER

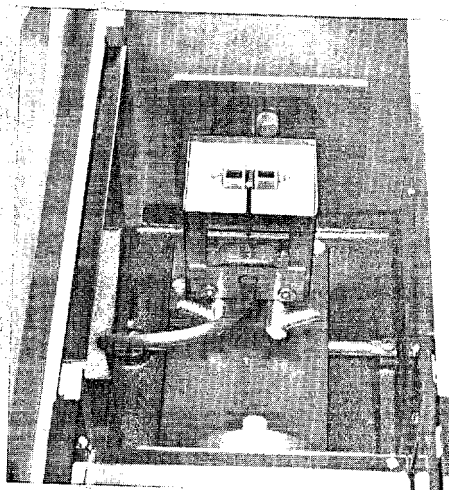


The solid sample holder quickly positions solid samples such as filters in a range of thicknesses from 0 to 40mm.

SPECIAL FEATURES OF THE SAMPLE COMPARTMENT

Note the baffled slots in the side panel in the photo above, for feeding electrical wiring or tubing into the compartment. This removable side panel is mounted so that its position with respect to the optical path is held to a high degree of accuracy. New and unusual accessories requiring accurate placement can be easily accommodated as substitutes for the removed side panel.

Thermoelectric controlled constant temperature cell and temperature detector for two 10mm square cu-



vettes can be set to any temperature over its range and it will regulate the temperature of the material within the cell.

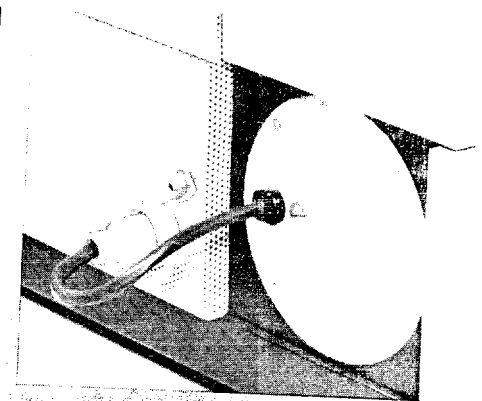
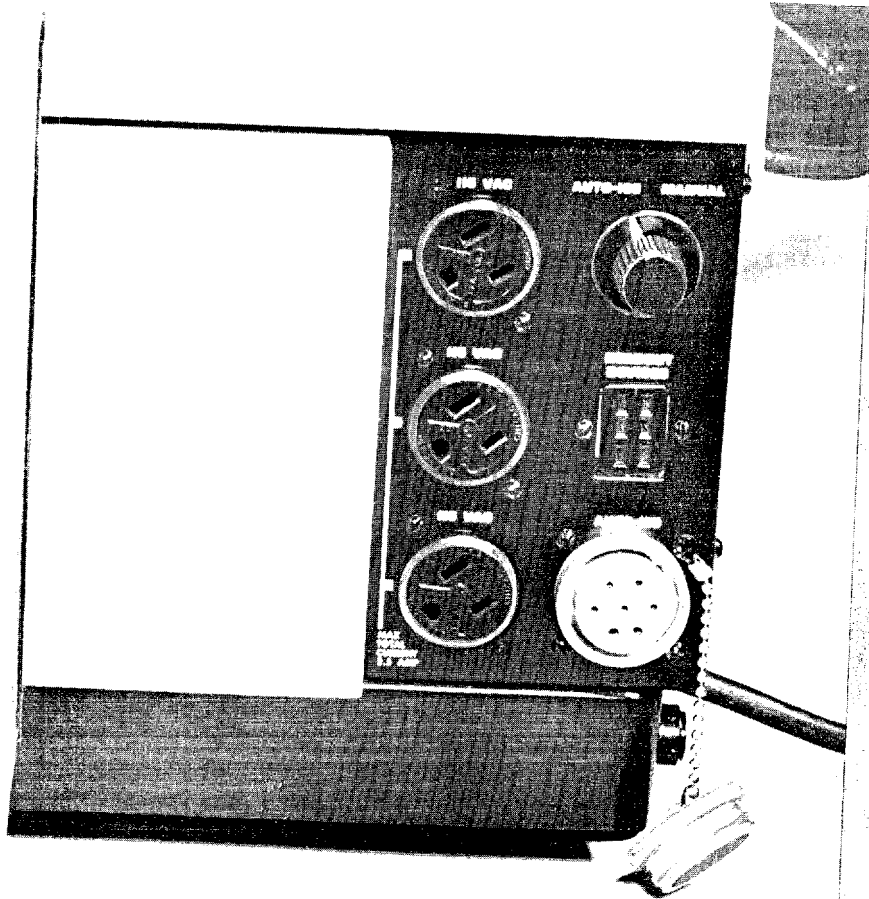
Temperature range is 5° to 100°C without water cooling; to -5.0°C with water cooling.

QUICKLY INTERCHANGEABLE OPTICS

Supplied as standard equipment, a 3 element quartz-fluorite focusing lens is located at the entrance to the sample compartment. Shown laying on the bench in the foreground, this lens forms an image of the monochromator exit slit at the image plane. The slit image is 10mm high and varies in width between .2 and 1.3mm, depending on slit setting.

For reading long or thick samples, a collimating lens may be substituted for the focusing lens. It is supplied with a 20, 15, 10, 5 and 2.5mm collimating disc having various size apertures so that the operator can select the beam diameter best suited to the sample being analyzed. The beam (cross-section) remains small and near constant over the entire 205mm length of the sample compartment.

The easy interchangeability of optics permits the user to substitute special optics for special applications.



SIMPLE ADJUSTMENT OF PHOTOMULTIPLIER

Adjusting for centration of the photomultiplier is accomplished in a matter of seconds. The two large screws in the center are the vertical and horizontal adjustments. You simply turn one until the meter peaks, then turn the other until the meter peaks.

When desirable, an end-on photomultiplier can be quickly substituted for the standard photomultiplier just by removing the four screws around the periphery of the housing, and unscrewing the electrical connection. No dessicant is required for the detector circuit.

CENTRAL "OPERATIONS" CENTER

A plug panel located on the side of the instrument within easy reach, is the central point for all plug-in's and accessories. It provides three AC outlets and accepts all accessory equip-

ment *without further adaptation.* The VOM-Recorders, AT-20 Digital Readout, Temperature Detector, etc., need simply be plugged in.

DESIGNED FOR QUICK NITROGEN PURGING

A gas connector located next to the photomultiplier is the terminus of a catacomb of internal tubing. To quickly purge the system with dry nitrogen, you simply connect a nitrogen tank with regulator to the gas outlet.



MODULAR DESIGN FOR RAPID SERVICING

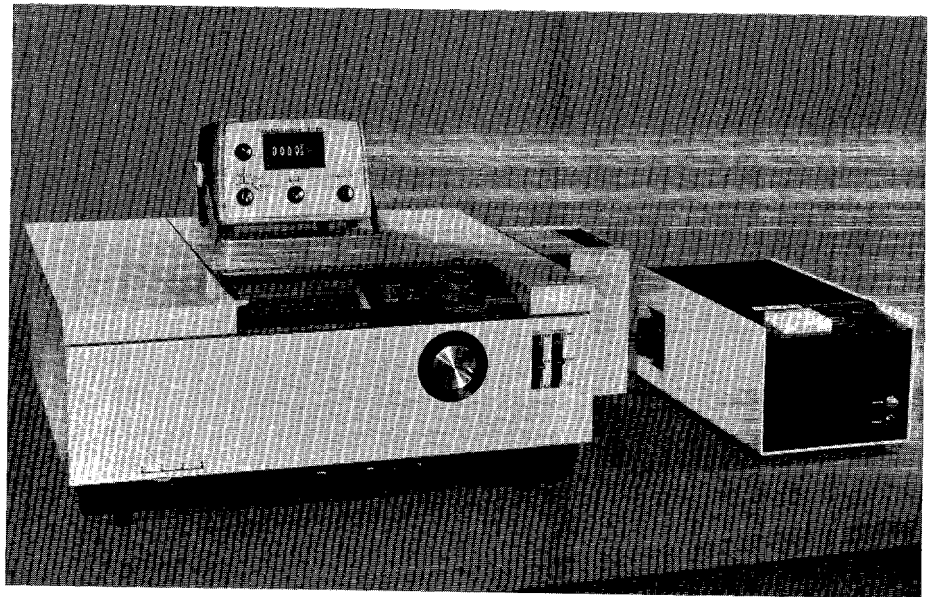
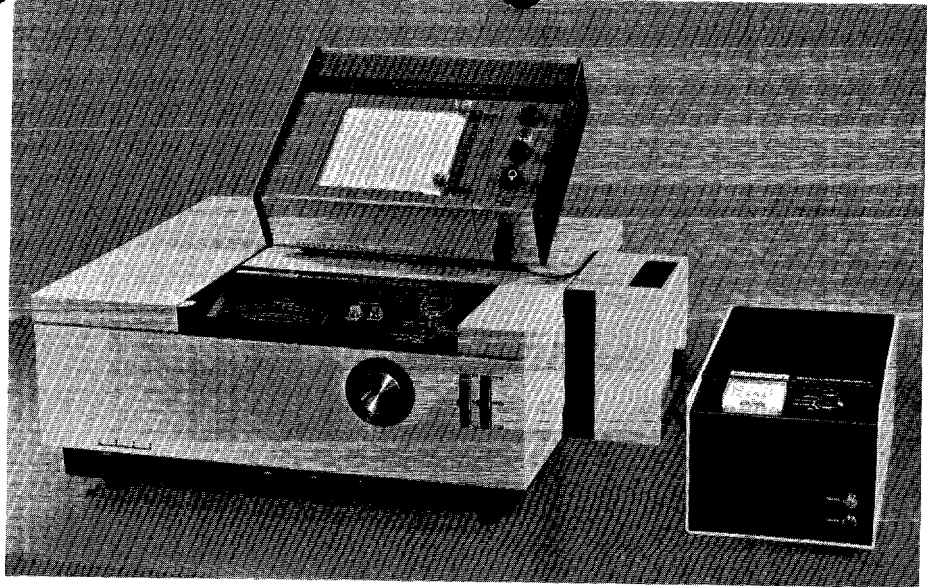
The entire electronic system can be quickly removed from the instrument for servicing. Several built-in test points and convenient slide-out printed circuit boards further add to ease of servicing.

The electronic chassis is a self ventilating design. A number of holes at strategic positions provide a continuously cooling convection current to flow past all critical components.

PRECISION SPECTROPHOTOMETER

PLUG-IN ACCESSORY READOUTS

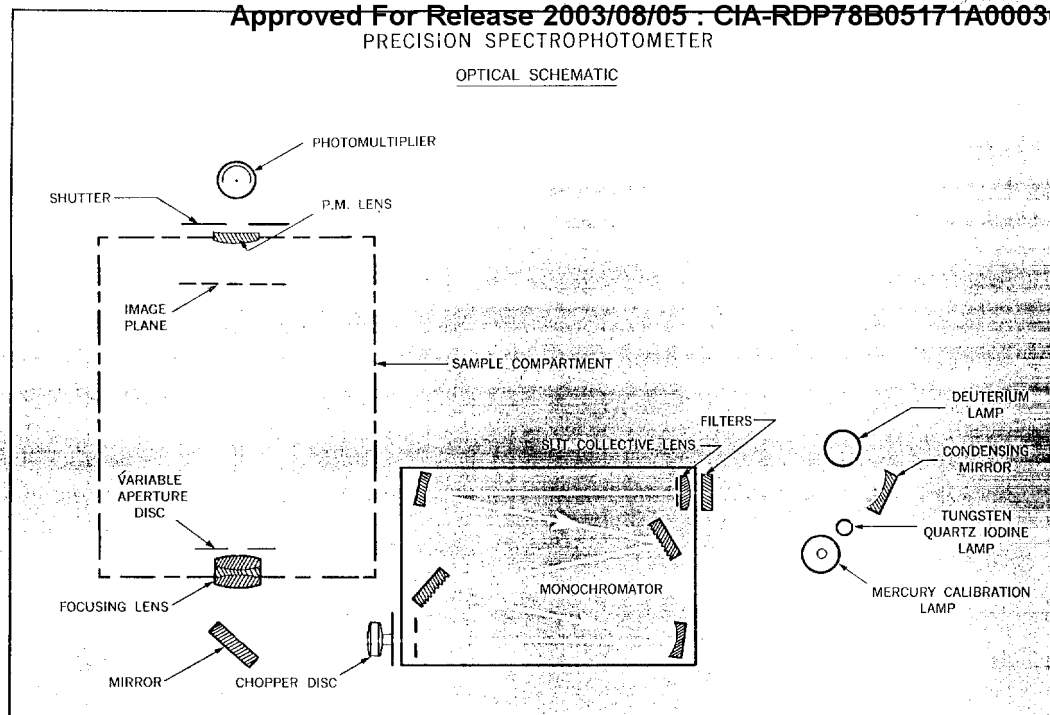
The At-20 Digital Readout or any of the Bausch & Lomb VOM-Recorders need only be plugged into the panel on the side of the instrument and are ready for immediate use. Values can be obtained in direct digital presentation in either transmittance or absorbance.



PRECISION SPECTROPHOTOMETER

PRECISION SPECTROPHOTOMETER

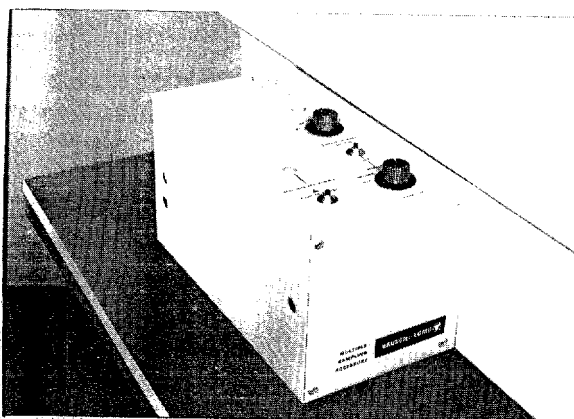
OPTICAL SCHEMATIC



SPECIFICATIONS

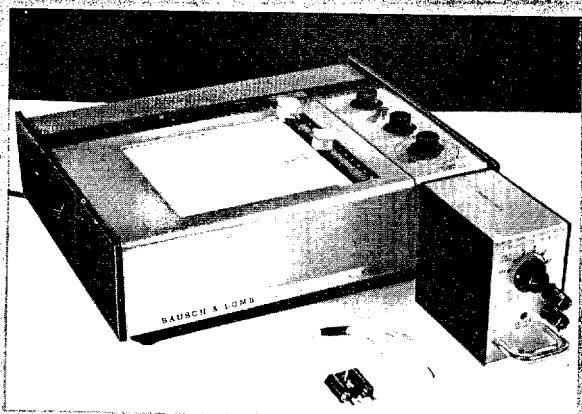
Wavelength range	190m μ —800m μ
Wavelength accuracy	Better than $\pm 0.2\text{m}\mu$ over entire range
Bandpass	Constant over entire range 0.2, 0.5 or 2.0m μ
Stray light	With Deuterium Source at 200m μ , — less than 0.3 %; at 220m μ —less than 0.1 % with Quartz-Iodine Source and Stray Light Filter at 260 m μ —Less than 0.5 %
Photometric Scale Expansion (Full Scale Values)	100%, 10% transmittance 0.0 to 1.5, 0.5 to 2.5 and 1.0 to 3.0 Absorbance
Photometric Accuracy	Better than 0.3 %
Photometric Reproducibility	Better than $\pm 0.1\%$
Electrical Linearity	Better than $\pm 0.1\%$ of full sensitivity on all ranges
Noise Level	Typical dark—Less than .01 % Typical signal—Less than .1 %
Gratings	Two Plane Reflection Gratings 1200 lines/mm; blazed for 200m μ
Power Requirements	107.5-127.5V., A-C, 210-250V., A-C., 50-60 cycles
Dimensions	Basic Instrument — 23" x 24" x 10" Lamp Power Supply — 15½" x 8¼" x 7" Lamp Housing — 7¼" x 5½" x 7½"

ACCESSORIES



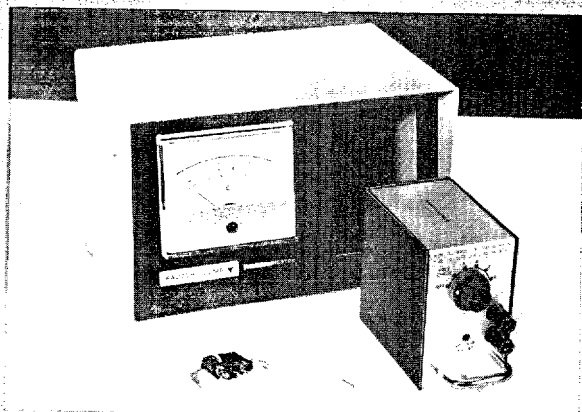
MULTIPLE SAMPLING ACCESSORY

The Multiple Sampling Accessory is designed to be used with the Precision Spectrophotometer for the study of kinetic reactions. The unit contains a Sample Holder immersed in a unique internal water bath for precise temperature control. The Sample Holder will accept five 10mm to 13mm test tubes or accessory 10mm square cuvettes, and place them sequentially into the Spectrophotometer's light path.



THERMOCORD

The thermocord permits precise monitoring of temperatures within the constant temperature cell. A thermistor probe is provided which can be easily inserted into either one of the apertures provided in the cover plate of the constant temperature cell. A switch on the unit permits setting to any one of 4 different ranges -96 to 152°C , 48 to 102°C , -2 to 52°C , -52 to 2°C , (does not include recorder).



THERMINDICATOR

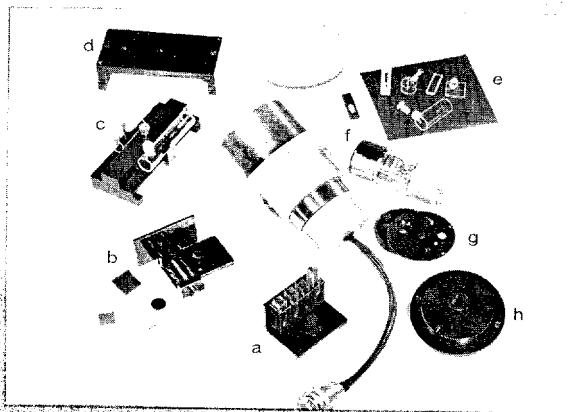
The thermindicator is the same as the thermocord except that the readout is by the meter rather than the recorder.

ADDITIONAL ACCESSORIES

A number of other accessories are available for use with the Precision Spectrophotometer. Several of them are shown in the illustration above.

- a. Four cell cuvette holder (supplied with basic equipment)
- b. Solid sample holder 0-40mm.
- c. Cylindrical cuvette holder.
- d. Stage adapter (supplied with basic equipment)
- e. A variety of cylindrical cells and square cuvettes.
- f. End-on photo multiplier and housing.
- g. Collimating lens with variable aperture disc.
- h. Adapter flange for use with emission accessories.

Other accessories available include a Flame Attachment, Reflectance Attachment and Fluorescence Attachment. Inquire for specific information describing these accessories.



PRECISION SPECTROPHOTOMETER

ORDERING INFORMATION

CATALOG NO.	DESCRIPTION	SUGGESTED LIST PRICE
33-26-50-01	Precision Spectrophotometer, UV-Visible, 190-700 mu. For 50 or 60 Hz (please specify) 115/230V, A.C. Complete with combination light source and power supply. With Quartz-Iodine, Deuterium and Mercury Lamps. With 1 set 10mm square silica cuvettes, dust cover and reference manual	\$4345.00
33-26-51	Adapter Flange for attaching flame and fluorescence accessories	50.00
33-26-52	End-on Photomultiplier housing	120.00
33-26-54	Specular Reflectance Attachment.	255.00
33-26-55	Solid Sample Holder.	75.00
33-26-56	Thermoelectric Heater-Cooler.	975.00
33-26-58	AT-20 Digital Readout	650.00
33-26-62	Cylindrical Sample Cell Holder, 28mm diameter	35.00
33-26-67	Collimating Lens and Aperture Plate	65.00
33-26-68	Cylindrical Sample Cell Holder, 22mm diameter	35.00
33-26-71	Cord set to connect V.O.M. Recorder to Precision Spectrophotometer	8.50
33-27-25	Silica Cuvettes with cover (set of two - 10mm square)	84.00
33-27-26	Pyrex Cuvette with cover (set of two - 10mm square)	54.00
33-27-27	Vycor Cuvette with cover (set of two - 10mm square)	66.00
33-27-28	Microcell Cuvette (one pair, Silica)	150.00
33-27-32	Silica Cells (cylindrical) with stoppers (set of two - 22mm diameter, 10mm length)	140.00
33-27-33	Silica Cells (cylindrical) with stoppers (set of two - 22mm diameter, 25mm length)	145.00
33-27-34	Silica Cells (cylindrical) with stoppers (set of two - 22mm diameter, 50mm length)	150.00
33-27-35	Silica Cells (cylindrical) with stoppers (set of two - 22mm diameter, 100mm length)	180.00
33-27-36	200mm Path Length Silica Cell (cylindrical) (set of two - 28mm diameter).	200.00
37-01-06-31	V.O.M.-5 Recorder for 105-125 Volts, 50-60 Cycles A.C. complete	675.00
37-01-66-31	V.O.M.-8 Recorder (Log-Linear) for 105-125 Volts, 50-60 Cycles, A.C. complete	995.00
37-01-23-24	Thermocord Accessory	185.00
37-01-23-25	Thermindicator Accessory	315.00

REPLACEMENT PARTS

33-26-61	4 Cell, Square Cuvette Holder	\$ 40.00
33-26-90	Photomultiplier, 1P28, Clear Window	65.00
33-33-14	Quartz-Iodine Lamp	22.00
33-33-26	Deuterium Lamp and Clamp	130.00
33-33-29	Mercury Lamp	1.45

BAUSCH & LOMB  ROCHESTER, NEW YORK 14602

PART NO.	DESCRIPTION
33-26-50-01	Precision Spectrophotometer, UV-Visible, 190-800mu. For 60 cycle 115-V, A.C. complete with combination light source and power supply. With Quartz-Iodine, Deuterium and Mercury Lamps. With one set 10mm square silica cuvettes, dust cover and reference manual
33-26-51	Adapter Flange for attaching flame and fluorescence accessories
33-26-52	End-on Photomultiplier housing
33-26-55	Solid Sample Holder
33-26-58	AT-20 Digital Readout.
33-26-62	Cylindrical Sample Cell Holder, 28mm diameter.
33-26-67	Collimating Lens and Aperture Plate
33-26-68	Cylindrical Sample Cell Holder, 22mm diameter.
33-26-71	Cord set to connect V.O.M. Recorder to Precision Spectrophotometer
33-27-25	Silica Cuvettes with cover (set of two - 10mm square)
33-27-26	Pyrex Cuvette with cover (set of two - 10mm square)
33-27-28	Microcell Cuvette (one pair, Silica)
33-27-32	Silica Cells (cylindrical) with stoppers (set of two - 22mm diameter, 10mm length)
33-27-33	Silica Cells (cylindrical) with stoppers (set of two - 22mm diameter, 25mm length)
33-27-34	Silica Cells (cylindrical) with stoppers (set of two - 22mm diameter, 50mm length)
33-27-35	Silica Cells (cylindrical) with stoppers (set of two - 22mm diameter, 100mm length)
33-27-36	200mm Path Length Silica Cell (cylindrical) (set of two - 28mm diameter)
37-01-06-31	V.O.M.-5 Recorder for 105-125 Volts, 50/60 Cycles A.C. complete
37-01-66-31	V.O.M.-8 Recorder (Log-Linear) for 105-125 Volts, 50/60 Cycles A.C. complete
37-01-23-24	Thermocord Accessory.
37-01-23-25	Thermindicator Accessory.

REPLACEMENT PARTS	
33-26-61	4 Cell, Square Cuvette Holder
33-26-90	Photomultiplier, 1P28, Clear Window.
33-33-14	Quartz-Iodine Lamp with retrofit kit for instruments built prior to 9/68
33-33-19	Quartz-Iodine Lamp
33-33-26	Deuterium Lamp and Clamp
33-33-29	Mercury Lamp.

MAY WE SEND YOU ADDITIONAL INFORMATION?

Bausch & Lomb manufactures many instruments essential to the well-equipped Laboratory, a few of which are shown below. Catalogs describing these instruments will be sent to you on request.

Concentration Computer Automatic method of obtaining concentration readings for any solution obeying Beer's Law. Electronic analog computer which can be used with any spectrophotometer having full scale output of 1.20 Volts D.C. Range: 0-2A or 100%-1% T. Meter expansion 2X and 5X. Catalog 33-6008.

Spectronic 505 Recording Spectrophotometer Directly records transmittance, absorbance, reflection and emission throughout UV and visible ranges, 200m μ -700m μ . Automatic speed control of the recorder slows its rotation as complex

spectra are encountered, allowing the pen additional time to precisely record the portions of steep slope in the curve. High dispersion and freedom from scattered light are features of the monochromator which utilizes two B&L "Certified Precision" Diffraction Gratings. Send for Catalog 33-2009.

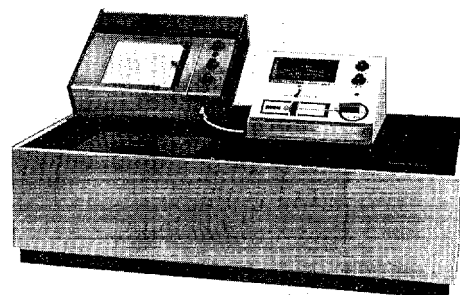
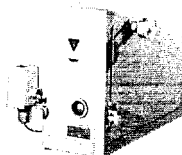
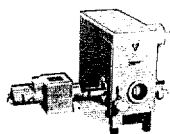
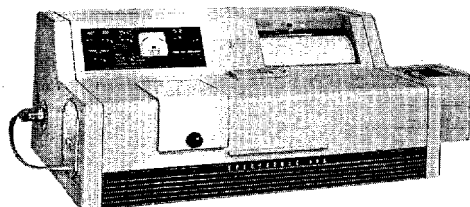
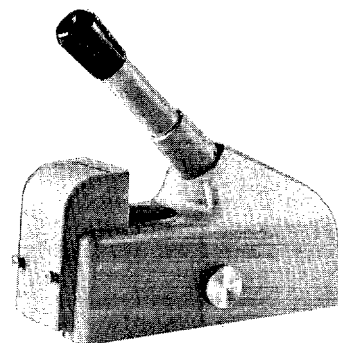
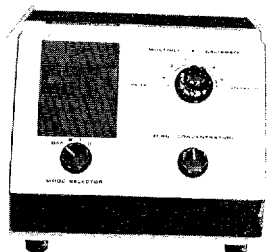
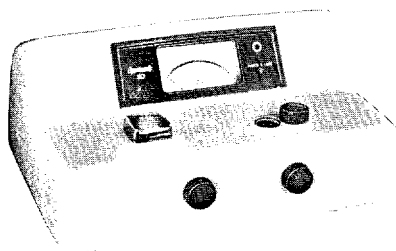
Spectronic 20 Colorimeter Both colorimetry and spectrophotometry handled with speed and precision by one low cost instrument. Single knob sets wavelength from 340 m μ to 950 m μ . Narrow bandpass (20m μ), high spectral purity. Catalog 33-266.

Monochromators 250mm, 500mm and High Intensity Models for every application. Wide variety of gratings to give any wavelength from

UV through IR. Light sources include Xenon, Deuterium, High Pressure and Super Pressure Mercury, Ribbon Filament Tungsten and Quartz Iodine. Catalog 33-2098.

Serum Protein Meter Permits a technician to do a total Protein Analysis in just 30 seconds to an accuracy of 0.2 grams/100 milliliters. Saves hours of time in the clinical laboratory, which processes hundreds of total Protein determinations in the course of a year. Catalog 33-2016.

Spectronic 600 Spectrophotometer. Double-beam, double grating, ratio-indicating. UV-visible range, 200m μ -650m μ , 3 synchronous scanning speeds—10m μ , 50m μ , and 250m μ /minute and forward and reverse slewing speeds. Wavelength accuracy and bandpass are constant—5A over the entire range. Catalog 33-2123.



high performance analytical instrumentation

Bausch & Lomb's NEW Analytical Systems Division provides a NEW dimension in customer-oriented analytical instrumentation and service

A highly competent technical staff continuously engaged in developing and improving optical and electronic equipment used for identification and measurement.

Established reputation for quality manufacturing assures trouble-free, high performance instrumentation to provide faster, more accurate, economical analyses.

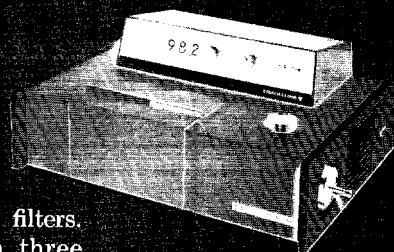
A fully equipped Applications Laboratory to assist you in providing the most simplified analytical methods and keep you abreast of rapidly changing technologies.

Regional Offices strategically located to give you prompt field service.

Electronic 100

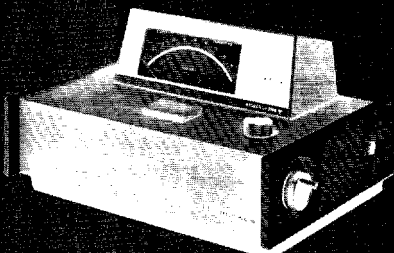
Automated simplicity... set wavelength (325-925 nm)—automatic system drives grating, interchanges phototubes and filters.

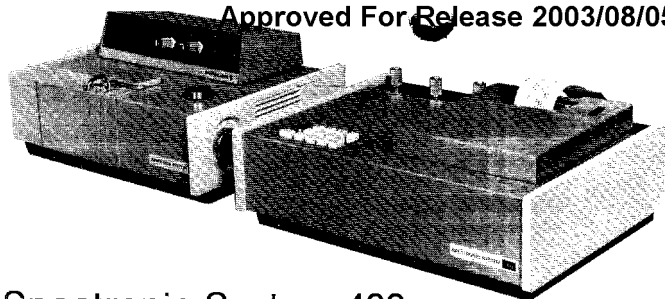
Four place readout in three modes—000.0% to 100.0%T, 0.000A to 2.000A, 0000 to 2000 in concentration, with selectable positioning of decimal point. Options of single, multiple and micro flow-thru cell compartments—accept test tubes, standard rectangular or cylindrical cells, or micro flow-thru cells. Has 8.0nm optical resolution. BCD output for recording and printout devices—analogue or digital. Catalog 33-6031.



Electronic 70

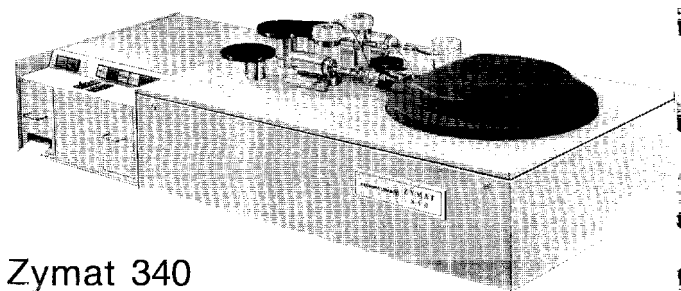
Easy operation—set wavelength, adjust for 100% T or 0.0A with reference, introduce sample and read. Wide, continuous 325-925nm range. All solid-state electronics with latest integrated circuit technology assure high stability, reliability, exceptional precision. Broad sampling flexibility for up-to-50mm path length cylindrical cells and rectangular cells—semi-micro, short path or constant temperature. Takes a variety of readouts. Catalog 33-6030.





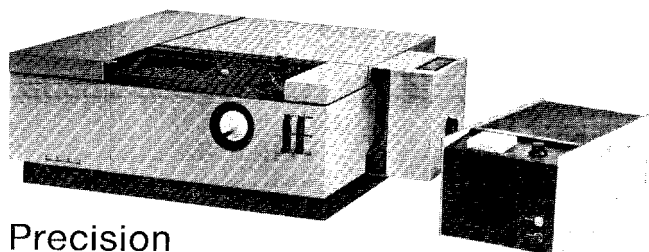
Spectronic System 400

A highly reliable, semi-automated system for rapid spectrophotometric analysis which provides instant selection of 4 operating modes: manual, semi-automatic, time/rate (6 sec.) and variable time/rate. Controls include sequential sample identification, accessory input and keyboard for manual data entry. 8-column print out. Simple, error-proof operation—built-in over-and-under range detector. Can process up to 400 samples/hour. Catalog 34-6032.



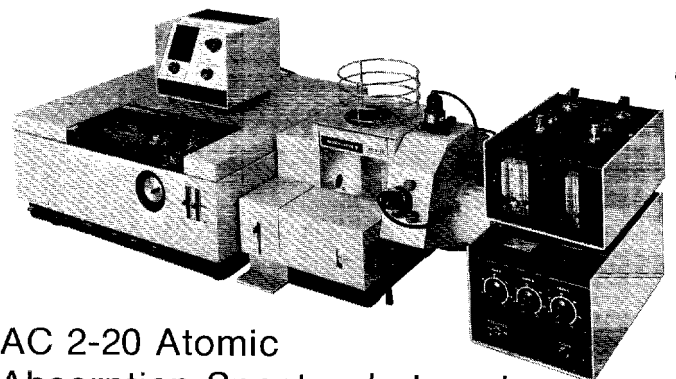
Zymat 340

The only completely automatic time-rate system of enzyme analysis. It provides highly accurate determinations of LDH, GOT, GPT and other enzymes of current interest. It utilizes approved wet chemistry methods in the classic kinetic reaction. Answers are printed out directly in International Enzyme Units (U) with identifying serial numbers. Catalog 34-6016.



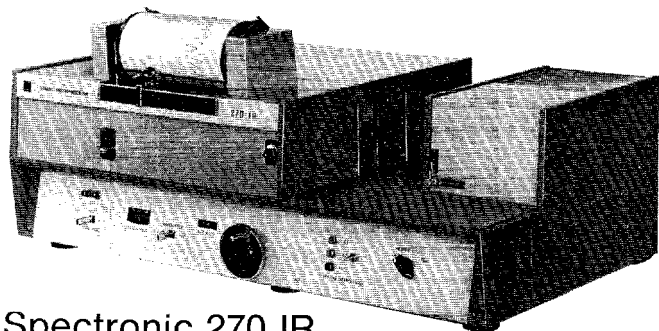
Precision Spectrophotometer

Precision performance and accuracy. Single beam. 190-800 nm wavelength range. Most versatile, convenient, easily operated instrument on the market, with complete line of accessories. Oversize sample compartment accommodates sample cells up to 200mm long. Built-in mercury lamp for positive wavelength calibration. Choice of bandpass—2A, 5A, or 20A—constant over entire range. Catalog 33-2151.



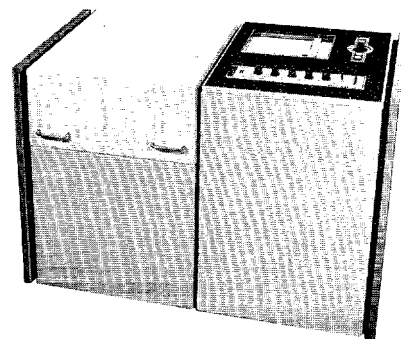
AC 2-20 Atomic Absorption Spectrophotometer

The AC 2-20 combines all the best features of up-to-the minute AA technology. Delivers top sensitivity and accuracy; combines safety, versatility, operator convenience with exceptional performance. The finest monochromator (two 1200 grooves/mm Certified-Precision Gratings) assures superior linear dispersion, eliminates adjacent interference lines. Catalog 33-2225.



Spectronic 270 IR Infrared Spectrophotometer

The Bausch & Lomb/Shimadzu Spectronic 270 IR makes infrared analysis simpler and more reliable than ever before. Automatic grating-and-filter interchange permits recording absorption spectra *continuously* over the entire 4000-400 wavenumber range—with *no scanning stop*. And a host of other advanced features. Catalog 39-6009.

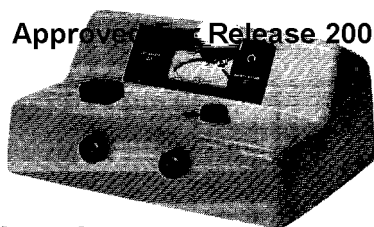


Spectrophor I

The ultimate in routine electrophoresis. Utilizes a unique fluid film agarose technique. No staining. Direct integrated readout. Separates 16 serum proteins in 20 minutes. Makes determinations of hemoglobins, iso-enzymes, lipo proteins, and spinal fluids. Complete wavelength versatility from 800-254 nm.

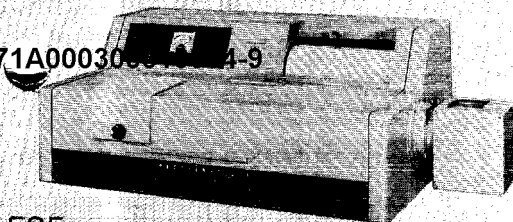
Spectronic 20

The world's most widely used spectrophotometer. Extremely easy operation, wide 340-950nm range, remarkable stability, low stray light, high sensitivity. Versatility further extended by a variety of accessories including the Concentration Computer for *direct* concentration readings. There are over 60,000 in use all over the world. Catalog 33-266.



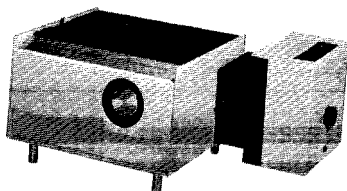
Spectronic 505 Spectrophotometer

The best buy in a double-beam, double-grating, ratio-recording spectrophotometer. Narrow, constant bandpass—5Å and 50Å standard. With reflectance attachment, it is an outstanding instrument for metamerism matching in color work. Write for Catalog 33-2009.



Double Grating Monochromator

High dispersion in a short path length; minimal stray light. Seven light sources and a wide selection of lenses and accessories make it more versatile than any other make. Uses two Certified-Precision Gratings in tandem. 190-825nm wavelength range (to 180nm by dry nitrogen purging). Bausch & Lomb manufactures a complete line of monochromators including 250mm, 500mm, and High intensity models. Catalog 33-2098.



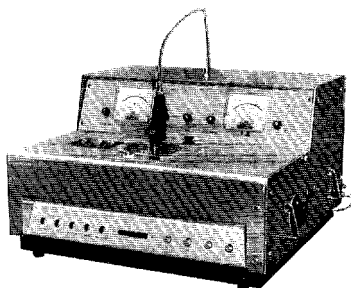
Spectronic 600 Spectrophotometer

3 synchronous scanning speeds—10m μ , 50m μ , and 250m μ /minute—forward and reverse slewing speeds make this a speedy, sensitive, and simple-to-operate instrument. Wavelength accuracy and bandpass constant—5Å over the entire range. Write for Catalog 33-2123.



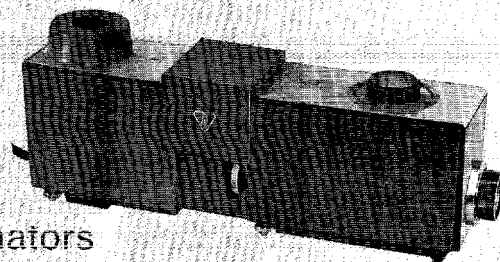
PGD

Fastest, easiest, most precise way of obtaining light scattering data. Measures the intensity and angular distribution of light scattered by polymer molecules in a suitable solvent. For determination of weight average molecular weight (M_w) in the 500 to 5,000,000 range and the Z average radius of gyration. PGD exceeds research standards and is unequaled as a routine industrial laboratory instrument. Catalog 39-6012.



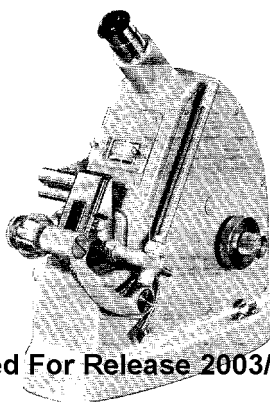
Monochromators

250mm, 500mm, and High Intensity Models for every application. Wide variety of Certified-Precision gratings to give any wavelength from UV through IR. Light sources include Xenon, Deuterium, High Pressure, and Super Pressure Mercury, Tungsten Ribbon Filament and Tungsten Quartz-Iodine. Catalog 33-2098.



Refractometers

World's most complete line for precision testing in every index range from n_D 1.20 to n_D 1.71, or percent total solids from 0-85%. Operation is fast, easy and so comfortable there's no fatigue... even after all day production use. Abbe 3-L, High range Abbe 3-L, Precision, Hand, and Juice Models. Catalog 33-202.



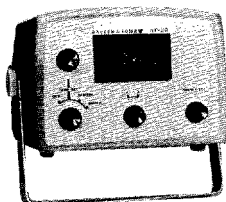
Concentration Computer II

Fast, simple, low-cost, fully automatic way to obtain concentration readings for any solution that conforms to Beer's law. Works with all Bausch & Lomb Spectrophotometers, can be adapted to many other meter instruments. Write for Catalog 33-6008.



AT-20 Digital Readout Accessory

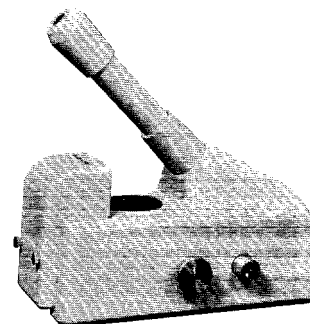
The AT-20 digital readout accessory for B&L's line of spectrophotometers provides you with the speed and accuracy of readout in digital form. The use of this unit for transmittance and absorption ratios is ideal with the Spectronic 20.



The AT-20 is a transistorized, servo-type digital meter. Control knobs are located on the front panel for convenience in use. The readout dial has been illuminated to permit easy, accurate readings under all conditions of room lighting. Catalog 33-266.

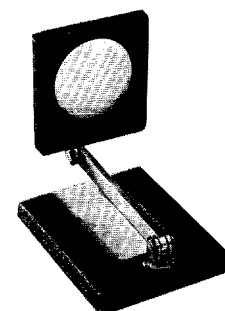
Serum Protein Meter

Permits a technician to do a total Protein Analysis in just 30 seconds to an accuracy of 0.2 grams/100 milliliters. Saves hours of time in the clinical laboratory, which processes hundreds of total Protein determinations in the course of a year. Catalog 33-2016.

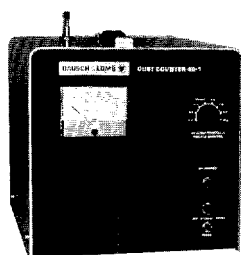


Educational Absorption Spectra Kit

The Bausch & Lomb Educational Absorption Spectra Kit offers a big advantage to the science teacher. It permits showing the spectrum and absorption bands to large groups of students in a manner they can clearly understand. This is done by projecting the spectrum onto a movie or slide screen. The only equipment needed to make the demonstration to students is the Kit and any standard 2" x 2" slide projector. Catalog 33-2079.



Dust Counter 40-1



A direct-indicating, electro-optical, light scattering particle detector capable of monitoring particles from 0.3 micron diameter to 10 micron diameter in concentrations of up to 10^6 particles per cubic foot. Particle selection is provided in seven increments; 0.3, 0.5, 1.0, 2.0, 5.0

and 10 microns, permitting a selective count of all particles greater than each set size. Qualifies for monitoring all three classes of clean rooms specified in federal standard #209. Catalog 38-2190.

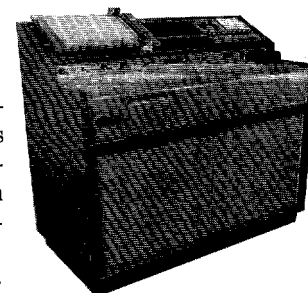
Hand Spectroscope

A direct vision type Spectroscope with an adjustable slit that is useful in qualitative work, with both emission and absorption spectra, where a wavelength scale is not required. Provides a quick, economical means of teaching students to recognize characteristic bright lines of metals and gases, transmission of colored glasses, and photographic safelights. The more prominent Fraunhofer lines are well shown. Catalog 33-27.



Spectropol I

An automatic recording spectropolarimeter which measures and records natural and magnetic optical rotatory dispersion (ORD and MORD) in addition to circular dichroism (CD) over a range of 190-600 nanometers. Featuring a double grating (1200 lines/mm) monochromator; ADP crystal polarizers; solid state, modular electronics; absolute rotation control system; zero line corrector for work with standard spectrophotometric cells; a flat, sliding recording table with matched damping for each scanning speed; a modulation and compensation of the faraday effect phenomena without mechanical motion; and a large ($6\frac{1}{2}'' \times 7'' \times 4\frac{3}{4}''$), easily accessible sample compartment. Catalog 39-6011.



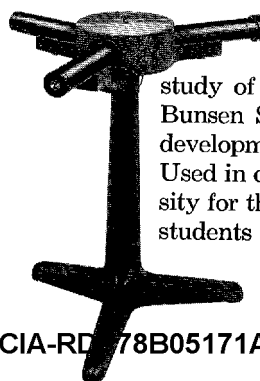
Certified Precision Diffraction Gratings

Bausch & Lomb provides gratings for every application—miniature to extremely large, plano or concave, with groove spacing from very coarse to the finest possible. A choice of over 2000 sizes and types makes it possible to select a grating blazed for maximum energy for practically every spectral region. Resolving power is always close to the theoretical.

Our catalog is filled with factual information; our price book lists hundreds of different gratings available for quick delivery. If your needs cannot be met by any of these, we can design one to your specific requirements. Catalog 35-261.

BAUSCH & LOMB  ROCHESTER, NEW YORK 14602
ANALYTICAL SYSTEMS DIVISION

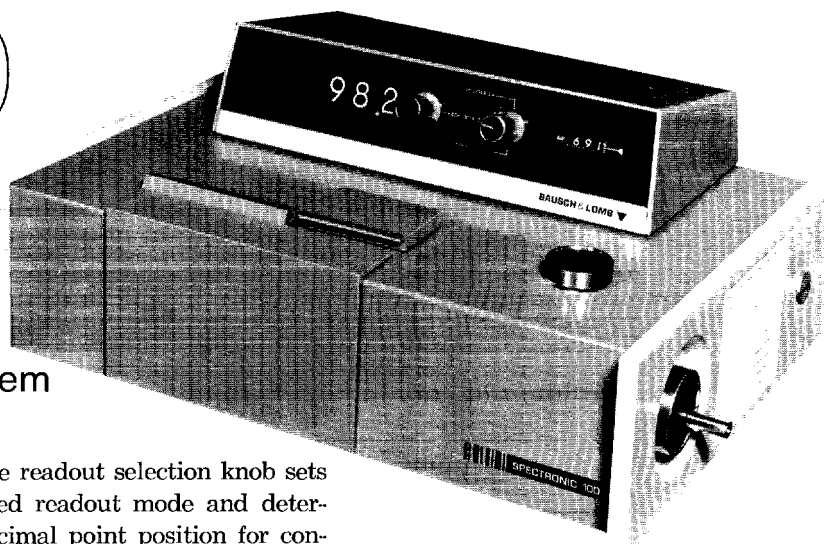
Bunsen Spectroscope



For instruction in qualitative analysis in science courses through the study of emission spectra, the Bausch & Lomb Bunsen Spectroscope contributes greatly to the development of a truly modern teaching program. Used in chemistry courses the Bunsen is a necessity for those projects undertaken by all levels of students either in class, team or individually, where a study of absorption characteristics is required. Catalog 33-27.

spectronic 100

- Four-place Digital Readout
- Three Modes: T and A, plus Concentration
- Wide Sampling Versatility
- Unique, Built-in Calibration System



The Spectronic 100 is one of the most versatile, yet accurate and reliable Spectrophotometers available in the medium price range. It provides the customer with maximum operational ease and instrument appeal as well as unprecedented measurement flexibility and versatility. It permits the analyst to read results in transmittance, absorbance, or absolute concentration units directly from single, multiple or micro-flow thru cells, using a digital nixie tube display. BCD output is available from a 40 pin connector at the rear of the instrument enabling the user to quickly and conveniently use any one of a variety of recording or printout devices—analogue or digital.

Wavelength range extends from 325-nm-925nm, with an 8.0nm bandpass. Readout is to four digits: in transmittance from 0.000-100.0%, in absorbance from 0.000 to 2.000 and in concentration from 0000-2000 with selectable positioning of the decimal point.

easy to operate

Four knobs constitute all the controls necessary to operate the instrument. The wavelength knob is completely free of backlash to assure precise set-

tings. The readout selection knob sets the desired readout mode and determines decimal point position for concentration. The remaining two knobs, which have an all-in-one coarse/fine adjustment to permit rapid but precise settings, control the concentration and 100.0% T (0.000A) adjustments.

speedy calibration

One of the most unique features of the Spectronic 100 is the built-in capability for simple electronic calibration which guarantees the electronic performance specifications over the life of the instrument. Precise calibration is speedily achieved through a calibration switch and screw driver adjustments readily accessible on the back panel.

uninterrupted wide spectral range

A continuous wavelength range of 325-nm to 925nm is available without interruption due to a wide range photo detection system utilizing two automatically interchanged phototubes. Both stray light, and second order filters, are used to insure exceptionally low

stray light throughout the entire wavelength range.

several sampling options

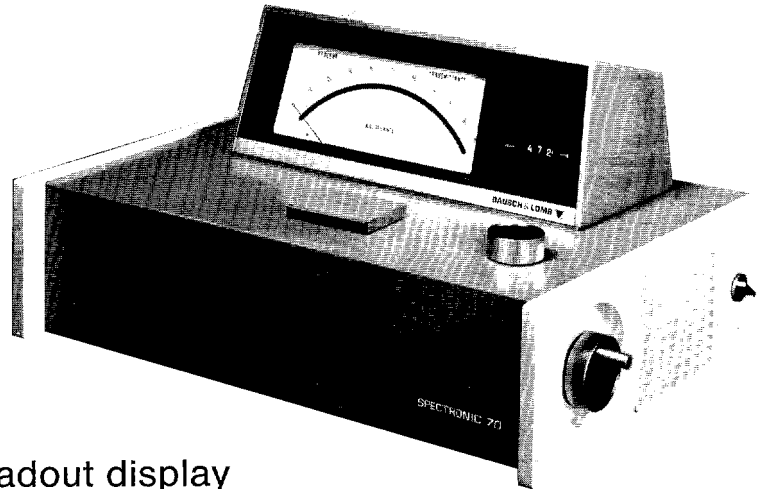
Three distinct models of the Spectronic 100 are available, permitting a choice of instrument suited to a particular application and budget.

1. **Spectronic 100-4**—Supplied with universal test tube holder and a front-loading single sample compartment.
2. **Spectronic 100-6**—Supplied with a front-loading multiple sample compartment that permits the operator to move sample cells into the light path in quick succession. A universal test tube holder may also be utilized.
3. **Spectronic 100-8**—Supplied with a micro flow thru cell compartment that requires a sample volume of only 0.5ml, and has less than 0.5% carry over. The compartment features a built-in logic which eliminates the possibility of drawing a sample into the cell until the previous sample has been evacuated and the cell purged.



Nixie tubes provide digital display to four places. Operator can quickly select one of three modes: transmittance, absorbance or concentration.

Excellent Performance
Simple Operation
Unequalled Versatility
Lowest Cost



The Spectronic 70 is completely new in concept, design and manufacture. Wide wavelength range, ease of operation and sampling versatility provide the analyst with a spectrophotometer that insures a number of advantages not available in any other instrument, even at twice the price.

Optical, electronic and mechanical specifications of the Spectronic 70 are outstanding. These are listed in this brochure and speak for themselves. The ease of operation and wide sampling versatility, however, must be demonstrated to be fully appreciated. There are no filters to insert, no filters to manually change—the instrument performs these functions automatically, smoothly, and with high precision.

uninterrupted wide wavelength range

Wavelength range of the Spectronic 70 is 325nm-925nm, continuous throughout the entire range. The wide range photo-detection system uses two automatically interchanged phototubes—no manual changing is required. Stray light and second order filters, which insure exceptionally low stray light over the entire range, also move in and out of the light path automatically.

large readout display

Photometric readout is derived from a wide 8-inch, mirror-scale meter. Fast acting and well-damped, the meter has an anti-parallax mirror backing to reduce the possibility of reading error. It is scaled in 0-100% linear transmittance and 0-2.0 absorbance units.

superior sampling versatility

Three distinct models of the Spectronic 70 are available, permitting a choice of instrument suited to a particular application and budget.

1. **Spectronic 70-2**—Supplied with universal test tube holder which accepts test tubes up to 20mm diameter and positions them to a precision of better than 0.5%.
2. **Spectronic 70-4**—Supplied with universal test tube holder and a front-loading single sample compartment for cuvettes or long path cells.
3. **Spectronic 70-6**—Supplied with universal test tube holder and a front-loading multiple sample compartment that permits the operator to move sample cuvettes or long path cells into the light path in quick succession.

ease of operation

The instrument has only two operating controls: One controls the occluder for 100% T adjustment; the other sets the desired wavelength. The entire operation to analyze a sample consists of:

1. Set wavelength
2. Introduce reference
3. Set 100% T or 0.000A
4. Introduce sample
5. Read transmittance or absorbance

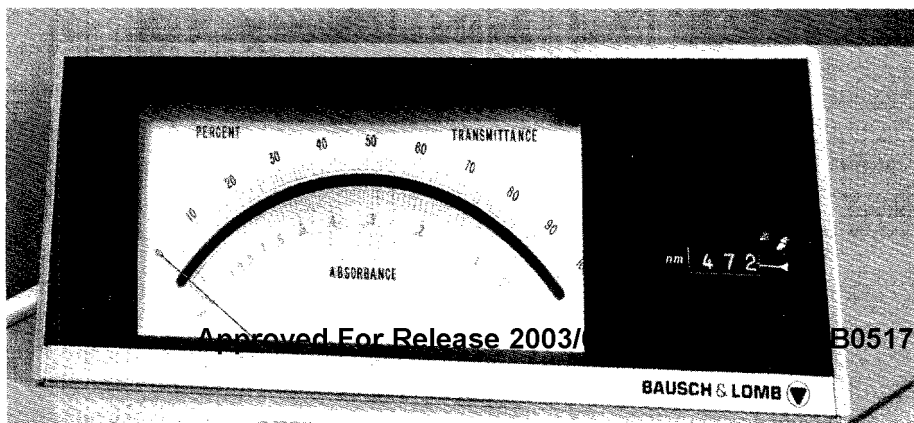
highly stable electronics

The electronics are all solid state combined with the latest in integrated circuit technology.

Exceptional precision in measurement is maintained by the all solid state a-c electronics system with virtually no zero drift, an extremely high degree of stability and low noise. The integrated circuits provide superb linearity characteristics and assured reliability. Modular design makes servicing a simple matter.

accessories

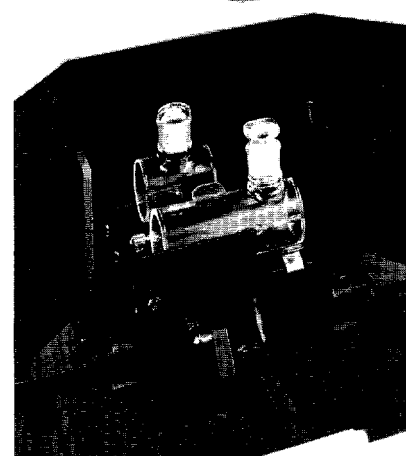
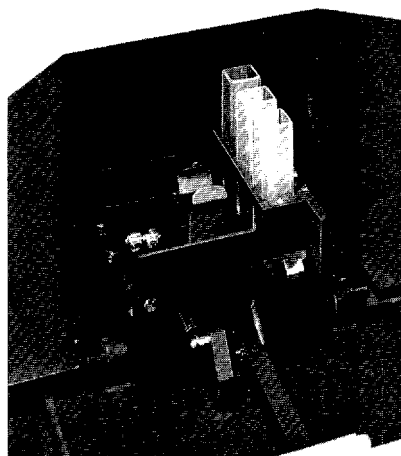
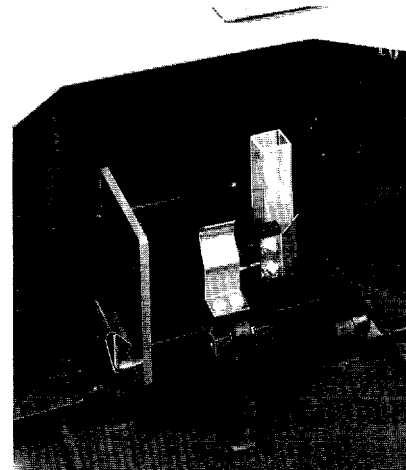
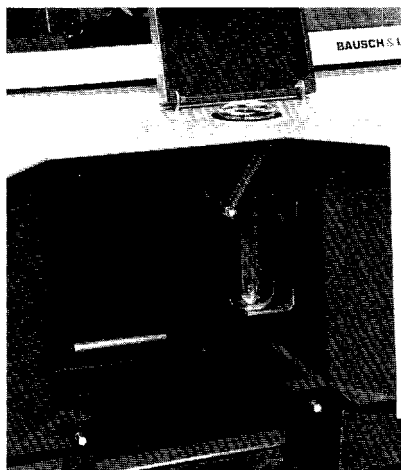
A six-prong accessory outlet on the rear panel permits instant attachment of a variety of readouts. These include the Bausch & Lomb V.O.M. series of strip chart recorders; the B&L AT-20 Digital Readout; the B&L Concentration Computer for direct concentration readings; and a three digit digital voltmeter for a nixie tube display.



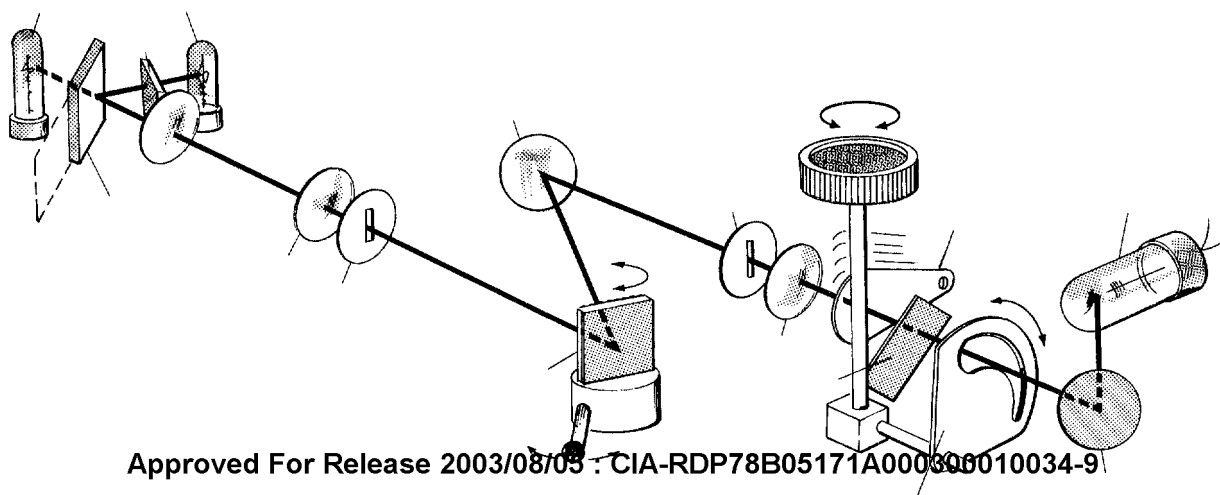
Wide, 8-inch, micro-scale meter is scaled in 0-100% linear transmittance and 0-2.0 absorbance. It is fast acting and well damped, with an anti-parallax mirror backing.

The optical system, which is the same in both instruments, combines fine accuracy and mechanical stability with ease of operation and accessibility.

- Tungsten Light Source that is a separate pre-aligned sub-assembly which permits quick, easy replacement.
- Dual action, coarse/fine adjust mechanical occluder with a 4 to 1 ratio, which serves as the 100% T (0.000A) adjust.
- Automatically inserted stray light filter which reduces stray light in the ultra-violet region.
- Off-axis, single grating monochromator, using a 1200 groove/mm B&L Precision Grating blazed at 3000A, with an f/5 entrance number and an f/10 exit number, resulting in a fast optical system which provides excellent signal-to-noise ratio for the detectors.
- Field lenses in both the monochromator and sample area. The monochromator field lens provides for maximum output of the optical system and low stray light. The sample compartment field lens permits the use of long path cells even with the fast optical system.
- Dual photo detection unit consisting of an S-4 (blue) and an S-1 (red) gas phototube in a unique low-voltage mode provides maximum stability and linearity. The S-1 phototube is equipped with a fixed second order filter.



Both the Spectronic 70 and Spectronic 100 offer incomparable sampling versatility—The user can choose the universal test tube adapter, single cell compartment, multiple cell compartment, or combinations of these. The universal adapter accepts test tubes up to 20mm diameter and positions them to a precision of better than 0.5%. Multiple cell compartment accepts three rectangular cells or two cylindrical cells, and filter plates up to 3" diameter. The Spectronic 100 is also available with a micro flow thru cell compartment.



Wavelength range: 325nm to 925nm
Optical bandpass (resolution): 8.0nm
Stray light: Less than 0.5% at 325nm
Wavelength accuracy: Better than 1.0nm
Wavelength precision: Better than 0.2nm
Photometric readout: Selectable in linear T, linear A, or concentration with digital presentation
Photometric range: 000.0 to 100.0 in T
0.000 to 2.000 in A
0000 to 2000 in concentration with selectable decimal point
Photometric linearity: Better than 0.2% in T
Better than 0.001A from 0.000A to 0.500A
Better than 0.002A from 0.500A to 1.000A
Better than 0.003A from 1.000A to 1.500A
Better than 0.004A from 1.500A to 2.000A
Photometric precision: Better than 0.1% in T
Better than 0.001A near 0.000A
Photometric noise level: Less than 0.1% in T
Less than 0.001A near 0.000A
Less than 0.003A near 1.000A
Less than 0.006A near 2.000A
Short term stability: (fifteen minutes) Better than 0.1% in T
Better than 0.001A near 0.000A
Better than 0.003A near 1.000A
Better than 0.006A near 2.000A
Long term stability: Better than 0.2% per hour in T
Better than 0.001A per hour in A
Zero drift (T only): Less than 0.2%/day
Accessory Output: Analog—Provides transmittance, absorbance, or concentration values at a level of 0.000 to 2.000 volts.
Digital—Provides BCD information for use with digital printers, data loggers, or computer interface.
a-c output—118 volts, 50/60 Hz, 2 amps.
Power requirements: 118 volts AC, 50/60 Hz, 100 watts.
(100, 220, and 240 volt, 50/60 Hz also available.)
Size: Width—17", Height—9", Depth—13½"
Weight: 38 lbs.

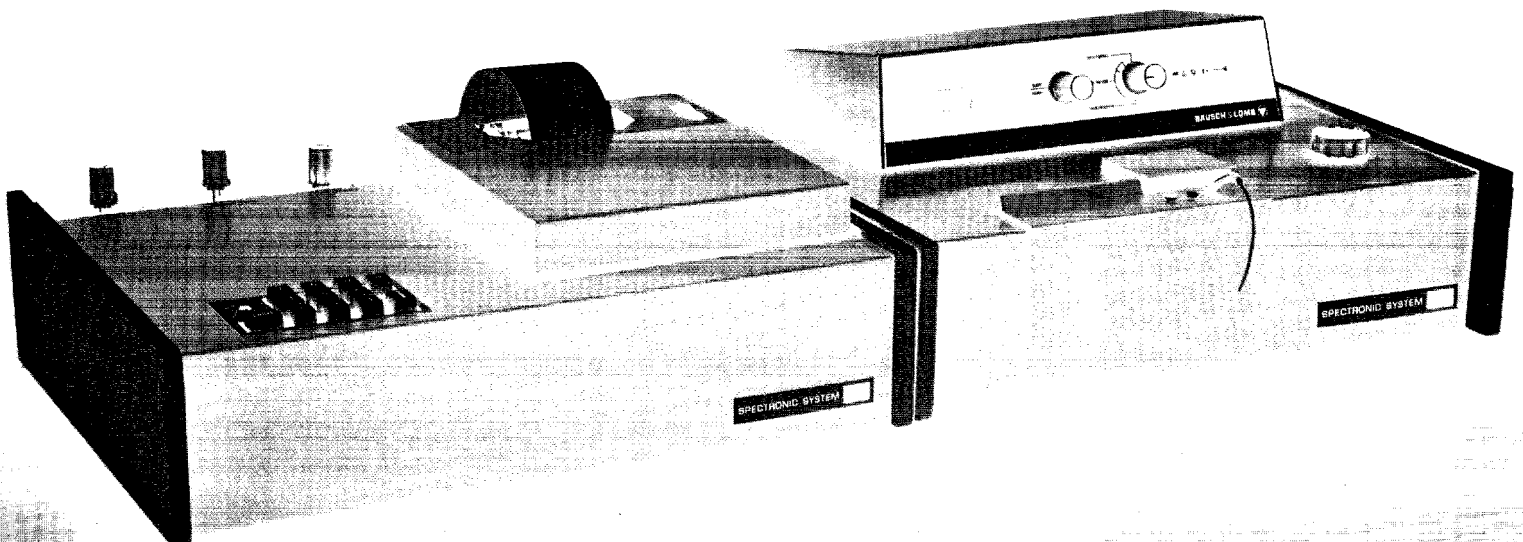
Wavelength range: 325nm to 925nm
Optical bandpass (resolution): 8.0nm (nominal)
Stray light: Less than 0.5% at 325nm
Wavelength accuracy: Better than 1.0nm
Wavelength precision: Better than 0.2nm
Photometric readout: 8" mirror scale meter
Readout in linear T and absorbance units
Photometric range: 0 to 100% in T
0 to 2.0 in A
Photometric linearity: Better than 0.5% with meter
Better than 0.2% at accessory terminal
Photometric noise level: Less than 0.1%
Short term stability: (fifteen minutes) Better than 0.1%
Long term stability: Better than 2.0%/day
Zero drift: Less than 0.1%/day
Accessory output: Provides transmission values at a level of from 0 to 1.0 volts
Power requirements: 118 volts AC, 50/60 Hz, 90 watts
100V, 220V and 250V also available
Size: Width—17", height—10", depth—13½"
Weight: 35 pounds

CAT. NO.	DESCRIPTION	FAIR TRADE PRICE
33-30-70	Spectronic 70-2, with universal test tube holder only	\$ 685.00
33-30-72	Spectronic 70-4, with universal test tube holder and single sample compartment....	\$ 775.00
33-30-74	Spectronic 70-6, with universal test tube holder and multiple sample compartment..	\$ 845.00

CAT. NO.	DESCRIPTION	SUGGESTED LIST PRICE
33-30-62	Spectronic 100-4, with single sample compartment	\$1,985.00
33-30-61	Spectronic 100-6, with multiple sample compartment	\$2,055.00
33-30-60	Spectronic 100-8, with Micro Flow Thru sample compartment	\$2,160.00

BAUSCH & LOMB  ROCHESTER, NEW YORK 14625
ANALYTICAL SYSTEMS DIVISION

spectronic system 400



spectronic system 400

... fast, accurate, reliable

The Spectronic System 400 is a highly reliable, semi-automated system for rapid spectrophotometric analysis over a continuous wavelength range of 325nm to 925nm, with a 8.0nm bandpass. Readout is to four digits: in transmittance from 000.0-100.0%, in absorbance from 0.000-2.000A and in concentration from 0000-2000 with selectable positioning of the decimal point. The operator can quickly

select one of four operating modes: manual, semi-automatic, fixed time-rate (at 6 second intervals) and variable time-rate. Controls include; sequential sample identification, accessory input and keyboard for manual data entry. Operation is simple, error proof with a built-in over-and-under range detector and display. The system can process up to 400 samples per hour via an 8-column printout.

components of the spectronic system 400 ... for greater precision and repeatability.

The Spectronic System 400 combines the multi-purpose Spectronic® 100 Spectrophotometer equipped with a micro flow-thru sample cell compartment and Nixie tube display with a sample programming—data processor, the DP-100. The DP-100 accepts the BCD output from the Spectronic 100 and prints out the stabilized values in numerical form—either on command or automatically. The DP-100 also generates the control commands to the micro flow-thru system by initiating the purge cycle when in semi-automatic.

Two lights on the front console of the Spectronic 100 signal the status of the sampling cycle. A red light indicates the sample flow in the cell—in or out. A white light indicates

that the purge cycle has been completed and the cell is ready to accept the next sample. Adjustments are provided for both the sample and purge time to eliminate carryover from one sample to another.

The DP-100 has circuitry for sequencing, controlling and timing in addition to printing. It also has provisions for time-rate measurements for the study of kinetic reactions. Manual data entry is possible via a keyboard.

Electronics, contained as part of the cable between the units, permit running the DP-100 at long distances from the spectrophotometer, and permit attachment of a recorder.

some advantages of the spectronic system 400

- Small, (0.5-1.0ml) sample.
- Greater precision and repeatability than systems utilizing smaller sample volumes.
- 400 samples per hour capability.
- Unique cell design and construction of KEL-F virtually eliminate bubbles.
- Cell status lights (red for sampling, white for next sampling) eliminate human error.
- Adjustable sample and purge times.
- No realignment required in micro flow-thru cell after removal for cleaning.
- Sample compartments can be changed in seconds.
- Cutoff filters can be used with cell in the micro flow-thru sample compartment for fluorescing samples.
- Direct printout of either absorbance, transmittance or concentration.
- Time-rate analyses can be performed at any wavelength from 325nm to 925nm.
- Multiple variants of time-rate modes may be chosen.
- Samples can be serially identified.
- Reads over 100% T—important when doing differential analyses.
- Non-linear reaction curves can be identified by combining a graphic display using a recorder and the numerical printout.
- Will accept any sample regardless of sample viscosity or volatility.
- Option available to purge manually with a liquid.
- The electronic modules are quickly removed and replaced to keep downtime at a minimum, when servicing is required.

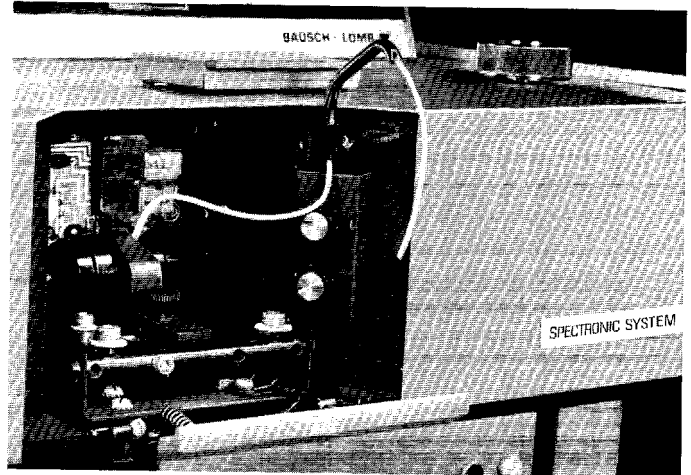
the sampling and purging electronics ... eliminate human error.

The electronics in the micro-flow thru system control a solenoid valve that regulates the operation of the vacuum source to the sample intake spout. Activating the solenoid pulls either air or liquids into the micro-flow thru cell.

The amount of sample depends on the amount of vacuum and the length of time the solenoid is activated. The electronics logic provides two independent control activate times. The normal sequence is for a sample to be loaded and read with the SAMPLE activation and then flushed out with the PURGE activation. An interlock operates so that once a sample has been entered, it must be purged before the next sample can be entered.

When a sample has been entered, a print command is given to the DP-100 to print the value of the sample in either absorbance, percent transmittance, or concentration.

Purging may be done either manually or automatically. Manually, pushing up on the sample intake spout draws in a sample; pushing down on the spout causes purging. The



logic indicator lights work in conjunction with this: a red light stays on while it samples—a white light indicates purging is over, system is ready for next sample.

a word about error detection

An error can be either an under-range or over-range and is sensed by the Digital Volt Meter. Any number less than 0000 is an under-range, and any number greater than 1999 is an over-range.

If an error is sensed there will be no printout, or a printout of 9's, depending on mode selected. Accurate values will be printed only if the sample has been corrected or a new, error-free sample is entered.

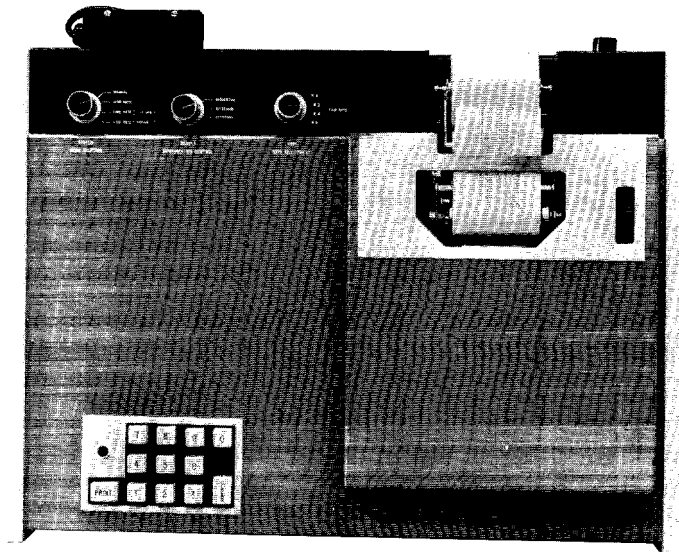
a look at the DP-100 Console

There are three knobs across the top of the DP-100 console. The System Mode Selector Knob has four positions: Manual, Semi-Auto, Time-Rate (1/10 min.), and Time-Rate (Variable). The Sample Identification Control has three positions: Sequential, Accessory, and Keyboard. The Time-Rate Adjustment has four time-rate variable intervals: 1X (6 sec.), 2X (12 secs.), 4X (24 secs.), and 8X (48 secs.).

The keyboard, located at the bottom, has keys from 0 to 9; a Print button, a Clear button and an error indicator light.

At the top right is the paper tape exit. A display of eight columns (seven columns are printed out, one is used as a divider) appears on the tape.

KEYBOARD: This mode can be used with either the Manual or Semi-Auto settings and permits entering any data up to seven digits. For example; date, time of day, wavelength, operator's number, or a determination code may be entered.



the display

The Display consists of an eight-column printout on paper tape. 8-7-6 5- 4-3-2-1

Counting from the right, the first four columns display the sample values.

Identification
Data
entered manually
by Keyboard

```

7 3 0 1 9 6 9
                    5 6
                    1 4 3
                    3 4 0
                    3 0
  
```

Column 5 is a blank column used as a divider and never shows a printed digit.

Columns 6-8 are normally for sample identification, and up to three significant figures may be printed.

Date
Operator Number
Determination Code
Wavelength
Temperature of Sample

```

0 0 0 0
0 2 0 0
  
```

Set Instrument for Zero Concentration
Set known Concentration of Standard

Automatic Printout
(in Sequential mode)

```

1 0 4 7 3
2 0 1 7 0
3 0 1 7 4
4 0 0 7 5
5 0 4 1 5
9 9 9 9 9 9 9
7 0 2 3 9
  
```

Sample No. 1
Sample No. 2
(Etc.)

Indicates sample is over or under Range

specifications of the spectronic system 400

Wavelength range: 325nm to 925nm

Optical bandpass (resolution): 8.0nm

Stray light: Less than 0.5% at 325nm

Wavelength accuracy: Better than 1.0nm

Wavelength precision: Better than 0.2nm

Photometric readout: Selectable in linear T, linear A, or concentration with digital presentation

Photometric range: 000.0 to 100.0% in T
0.000 to 2.000 in A
0000 to 2000 in concentration with selectable decimal point

Photometric linearity: Better than 0.2% in T
Better than 0.001A from 0.000A to 0.500A
Better than 0.002A from 0.500A to 1.000A
Better than 0.003A from 1.000A to 1.500A
Better than 0.004A from 1.500A to 2.000A

Photometric precision: Better than 0.1% in T
Better than 0.001A near 0.000A

Photometric noise level: Less than 0.1% in T
Better than 0.001A near 0.000A
Less than 0.003A near 1.000A
Less than 0.006A near 2.000A

Short term stability: (fifteen minutes) Better than 0.1% in T
Better than 0.001A near 0.000A
Better than 0.003A near 1.000A
Better than 0.006A near 2.000A

Long term stability: Better than 0.2% per hour in T
Better than 0.001A per hour in A

Zero drift (T only): Less than 0.2%/day

Accessory Output Analog—Provides transmittance, absorbance, or concentration values at a level of 0.000 to 2.000 volts.
Digital—Provides BCD information for use with digital printers, data loggers, or computer interface.
a-c output—118 volts, 50/60 Hz, 2 amps.

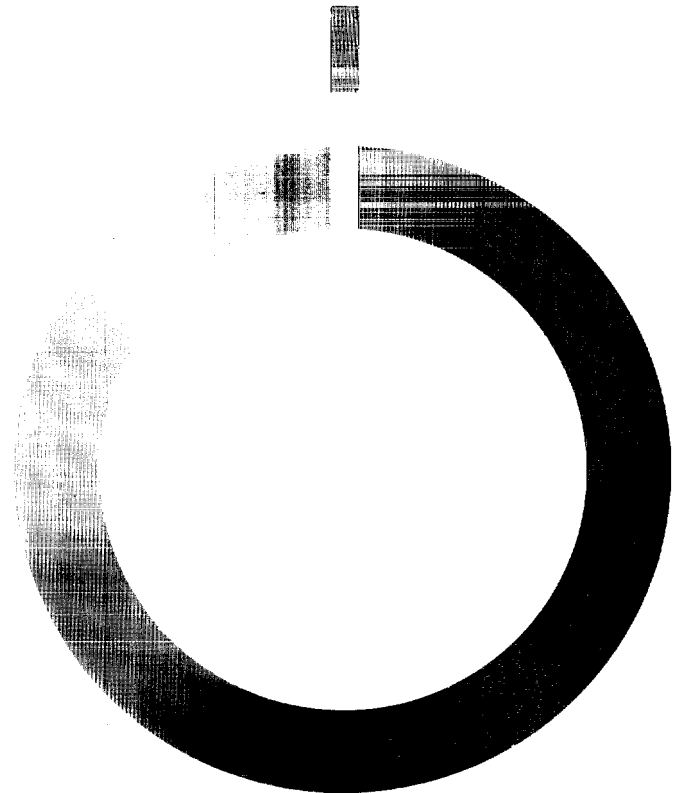
Power requirements: 118 volts, 50/60 Hz, 100 watts.
(100, 220, and 240 volt, 50/60 Hz also available.)

Size: Width—17", Height—9", Depth—13½"

Weight: 38 lbs.

BAUSCH & LOMB  ROCHESTER, NEW YORK 14625
ANALYTICAL SYSTEMS DIVISION

grating monochromators



Bausch & Lomb provides the most complete line

There is a Bausch & Lomb Monochromator for your application that will provide high efficiency, ease and convenience of operation, at the lowest cost. Thousands of B&L Monochromators are presently in use in every segment of industry, education and research.

Designed as illuminators to provide pure monochromatic light of high intensity in the ultraviolet, visible and infrared regions, B&L Monochromators are invaluable in almost any monochromatic application. As source units they can be combined readily with other equipment for spectrophotometry and photomicroscopy. Some applications are in spectroradiometry, including studies in luminescence, and fluorescence, in cancer research projects, cell composition, body fluids, dermatology, plant and insect studies, and many others in Biochemistry, Biology, Botany, Ophthalmology, Physiology and Psychology, Physics and Chemistry. In industry B&L Monochromators are used for research in rocketry and communications systems, for evaluation of photomultiplier tubes, calibration of solar cells and other solid state devices, testing filters and transistor components, as well as in quality control in the production of these materials.

B&L gratings assure high dispersion and purity

The grating used in Bausch & Lomb Monochromators are manufactured in the David Richardson Grating Laboratory, a unique Bausch & Lomb facility, in which the majority of the world's most precise gratings are manufactured. No other commercial facility exists that can produce gratings of equal quality. The purchaser of a Bausch & Lomb Monochromator can always depend upon obtaining top performance throughout the entire wavelength range.

Bausch & Lomb Grating Monochromators offer many advantages over prism instruments:

- Complete monochromatic systems can be supplied at lower cost than comparable prism type systems.
- A grating provides greater dispersion than a prism and this dispersion remains constant throughout the entire wavelength range. Wavelength presentation of a grating is linear; bandpass and resolution do not change with wavelength.
- Calibration of a grating instrument is simple, but calibration of a Prism instrument is a difficult, time-consuming task.
- Several expensive prisms are required to span the same wavelength range covered by one grating, when there is a need for maximum transmission and dispersion.
- Because of the higher dispersion of a grating instrument, the flux transmitted by the monochromator (for the same source, bandpass and equivalent aperture ratio) is greater than that provided by a prism instrument.
- Grating instruments provide greater versatility of application. In addition to the grating or gratings supplied as standard equipment, a variety of other gratings are available, any one of which can be substituted easily in the field.

An instrument for every application

There are four basic configurations in the standard line of Bausch & Lomb Monochromators—the Double Grating Monochromator, the 250mm Monochromator, the 500mm Monochromator and the High Intensity Monochromator. Several different models are available in each of these 4 classes, offering a broad choice from which you can select the instrument exactly suited to your own specific application. Ready interchangeability of gratings and light sources within each class provide a wide versatility for meeting both present and future requirements.

In addition to the standard instruments, special monochromators can be built to meet specific requirements. Although such custom equipment will cost more initially, it will often pay for itself quickly in the time saved and in more accurate results. We will be happy to consult with you on building an instrument tailored to your requirements.

monochromators

Bausch & Lomb 250mm and 500mm monochromators

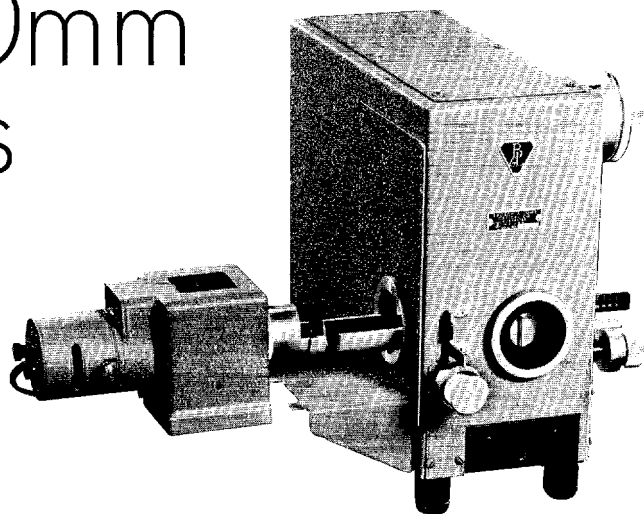
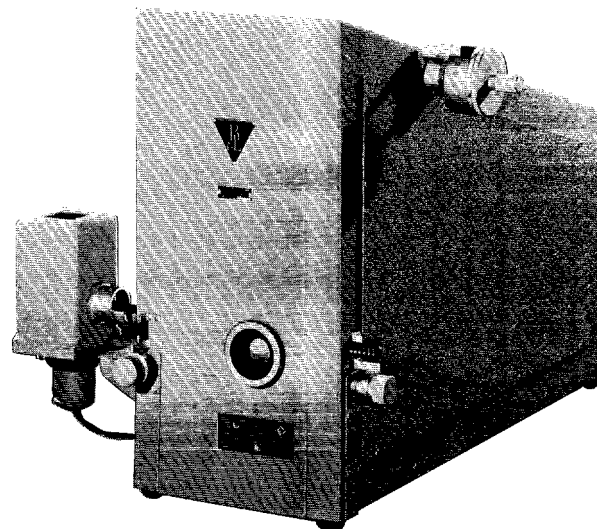
The 250mm and 500mm models are similar in construction, with many features common to both. The following description will therefore apply to both instruments except where noted.

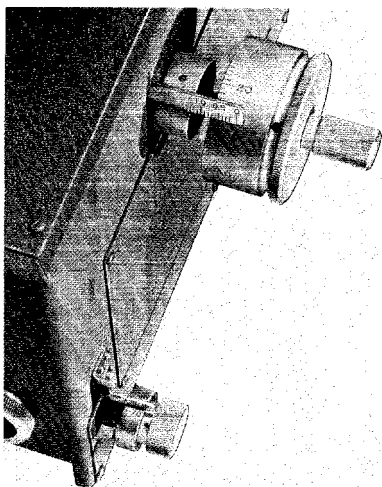
certified precision grating.

The grating supplied in the standard 250mm and 500mm Monochromators is a 600 groove/mm reflection grating blazed for maximum efficiency at 300 nanometers in the first order. The grating is replicated in aluminum, deposited on blanks either 80mm or 160mm in diameter.

The 250mm and 500mm Monochromators offer the option of a 300 groove/mm, or a 1200 groove/mm plane reflecting grating. The 1200 groove/mm grating is blazed for maximum efficiency at 300 nanometers in the first order, while the 300 groove/mm grating is blazed for 1.0 micron. Grating ruled area for the 500mm Monochromators is 102mmx102mm and for the 250mm Monochromator is 52mmx52mm.

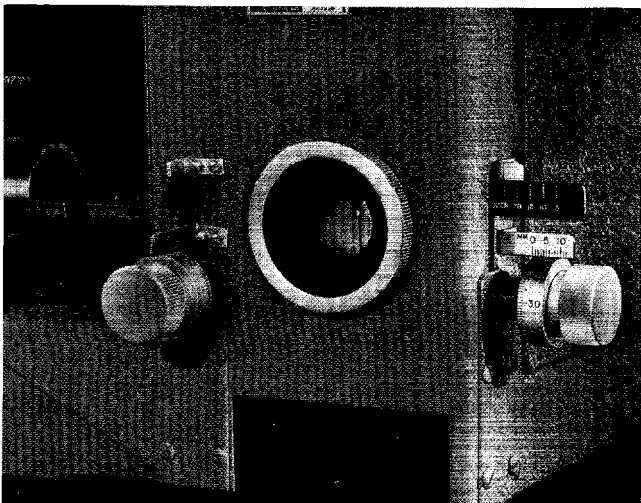
To achieve maximum efficiency in other regions of the spectrum, gratings with different blaze wavelengths and different number of grooves/mm can be supplied. These may be substituted for the standard grating on the original order or purchased as additional equipment. In any case, gratings will be supplied in mounts for ready interchange by the operator.





grating mount and wavelength readout

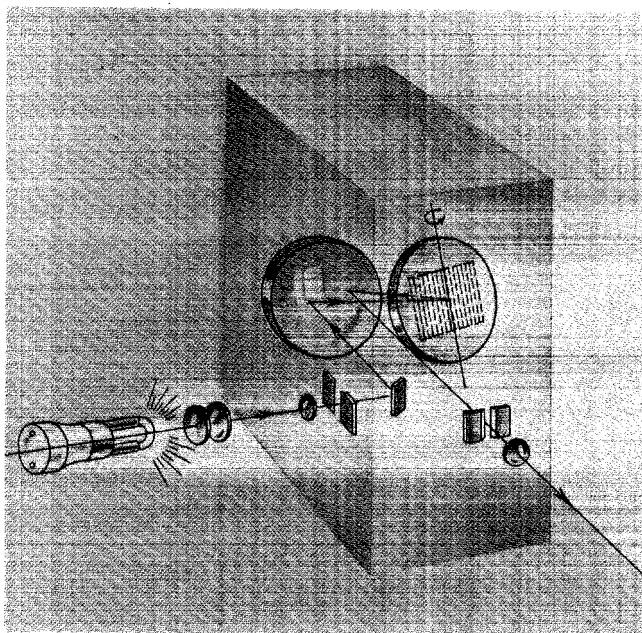
The grating mount rotates, to place different wavelengths on the exit slit. Selection of wavelength is made by turning the graduated wavelength drum, which activates a sine bar linkage within the instrument, thereby rotating the grating mount. The sine bar linkage provides for a strictly linear wavelength presentation. The wavelength drum used in conjunction with a vernier is graduated in nanometers and can be read accurately to $\frac{1}{2}$ division. Monochromators with a 300 groove/mm grating are equipped with a drum and index plate for a range of 0 to 3000nm. With a 600 groove/mm grating the drum and index plate cover the range from 0 to 1500 nm, and with a 1200 groove/mm the range is 0 to 750nm.



variable slits

The 250mm and 500mm Monochromators are equipped with variable slits. Both the entrance and exit slits are identical, bilateral (symmetrically opening) slits. The jaws are operated by a double screw with an effective pitch of one millimeter. The slit opening can be read directly to 0.01mm from a small scale which indicates full turns of a screw and a graduated drum which indicates hundredths of a turn.

Accuracy of slit width is adequate for all but very high precision work.



optical system

Light from a lamp passes through a fused silica entrance condensor and collector lens system and illuminates the entrance slit. From the illuminated slit, the light is directed by a small plane mirror to a concave mirror and is then dispersed by a plane reflecting diffraction grating. The dispersed light is incident on the same concave mirror which forms an image of the entrance slit on the exit slit. Since the mirror acts in a dual capacity as collimator and telescope, it is necessarily larger than the parallel beam. This insures that the full aperture is obtained in both the entering and dispersed light beams.

A quartz collector lens at the exit slit forms a 12.5mm square image of the grating at a point about 60mm in front of the monochromator housing. An achromatic condenser lens (Cat. No. 33-86-53) is available which will form an image of the slit instead of the grating. It also eliminates the need to refocus for different wavelengths. This is covered in greater detail on Page 11.

specifications

250mm and 500mm grating monochromators

Linear Wavelength Scale	Factory-set. No calibration required.		
Certified-Precision Grating	High Efficiency, Constant Bandpass		
Compact	<div> <div>250mm</div> <div>500mm</div> </div>	<div> <div>32cm x 14cm x 30cm</div> <div>63cm x 24cm x 49cm</div> </div>	<div> <div>12½" x 5⅜" x 11¾"</div> <div>24¾" x 9¼" x 19⅜"</div> </div>
High Spectral Purity	Less than .1% of Stray Light at 300nm		
Wide Range	200–1400nm in first order		
Achromatic	Reflecting optics—no focusing required for different wavelengths		
High Linear Dispersion	<div> <div>250mm—6.6nm/mm</div> <div>500mm { 3.3nm/mm 1.65nm/mm 6.6nm/mm</div> </div>		
Wide Range Slits	12mm x 20mm adjustable		

features

Focal Length	250mm	600mm	500mm (Optional)	500mm (Optional)
Grating Area	52mm x 52mm 600 grooves/mm	102mm x 102mm 600 grooves/mm	102mm x 102mm 1200 grooves/mm	102mm x 102mm 300 grooves/mm
Dispersion	6.6nm/mm (first order)	3.3nm/mm (first order)	1.65nm/mm (first order)	6.6nm/mm (first order)
Grating Efficiency	65% at 300nm	65% at 300nm	65% at 300nm	65% at 1000nm
Range	200–1400nm (first order)	200–1400nm (first order)	200–700nm (first order)	200–2800nm (first order)
Equivalent Focal Ratio	f/4.4	f/4.4	f/4.4	f/4.4

light sources

Bausch & Lomb offers an extensive group of light sources for most applications. It is possible to use a presently owned source or to purchase a special source for specific applications. Although sources other than B&L units can be used, the optical system has been designed specifically to match all B&L light sources with the monochromator. Thus for maximum efficiency and optimum performance, a B&L light source is recommended. If optimum performance is not required, other sources may be used. Alternately, optimum performance can be obtained with other sources if a suitable optical system is designed, built, and installed.

Seven interchangeable Bausch & Lomb light sources are available for selection, according to the spectral region required and the type of spectrum (either continuous or line) desired. See "ORDERING INFORMATION" on Pages 14 and 15 for a complete listing of all light sources and the monochromators with which they can be used.

1. xenon light source

The emitting element of this lamp is a short electric arc in high pressure xenon contained within an envelope of fused silica. It is a high intensity, continuous source which operates at a power level of 150 watts, and 25000 volts R.F. The R.F. energy is confined to the interior of the lamp housing, thus eliminating hazard to personnel. The lamp envelope transmits from wavelengths shorter than 200nm to wavelength longer than 3.5 microns. In the visible region, this lamp has a color temperature of about 5000 Kelvin. Brightness distribution is 96 candles per square millimeter over an effective area of 0.75mm x 1.50mm. Lamp life is approximately 1000 hours.

The power supply is a separate, compact unit—9 1/4" x 14 1/2" x 7 3/4" with an on-off switch and pilot lamp.

One of the outstanding features of this Xenon source is its high stability. There is none of the flicker that is characteristic of other Xenon sources.

2. air cooled deuterium arc source

The emitting element of this lamp is a D.C. arc in Deuterium contained within an envelope of fused silica. The useful spectral range is from 200nm to 400nm only. It is, therefore, strictly an ultraviolet source, and is recommended for work requiring continuous spectral illumination in the UV.

The power supply contains a full wave rectifier for converting AC to DC and a special circuit for starting the lamp. Also included in the unit are an ammeter to monitor the current setting, pilot lamps and an on-off switch.

3. super pressure mercury source

This is a 200 watt mercury vapor lamp with a fused silica envelope. It is supplied with a fused silica condenser system and an AC power control unit. It is recommended where a very high intensity emission spectrum (line spectrum) is required. However, the very high pressure in the

lamp broadens the emission lines appreciably and superimposes a low level continuum upon the line spectrum.

4. high pressure mercury source

This lamp is similar in most respects to the Super Pressure Mercury Source but operates at 100 watts. It also has a fused silica envelope and condenser system and an AC power control unit. Because of the lower power level, the pressure in this lamp is less than in the Super Pressure Source. Consequently, the pressure broadening is less and the continuum is at a lower level.

5. coil filament (tungsten-halide) source

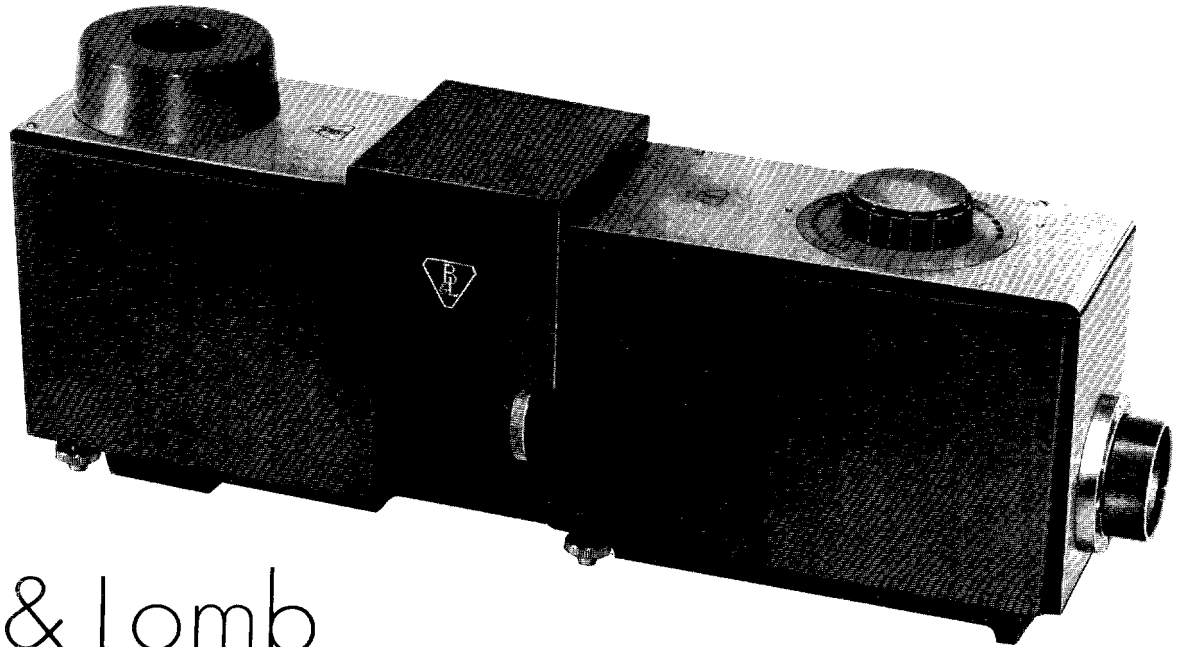
This source is frequently called a "quartz-iodine" lamp. It is a coiled tungsten filament operating at 6.8 volts and 45 watts. The envelope is made of fused silica and it contains a halogen, usually iodine or bromine, which is found to prolong the filament life and prevent darkening of the bulb. The source is supplied with a fused silica condenser system. The transformer is an integral part of the lamphouse. It provides a continuous spectrum and is recommended for use in the near UV, visible, and infrared regions.

6. tungsten ribbon filament source

This filament operates at 6 volts AC and 18 amperes. It emits a continuous spectrum from 300nm into the far infrared. The transformer is part of the lamphouse. The use of a ribbon filament assures a more uniform, or homogeneous, brightness than can be obtained with a coil filament but there is some reduction in output.

7. dual light source

The Dual Light Source can be used only with the Double Grating Monochromator and consists of a Deuterium Source, a Tungsten-Halide Source, Power Supply and Adapter Box. The fully transistorized power supply provides a very well regulated current and potential source for the lamps. It is mounted on the lamp house. The power supply provides a constant current for the Deuterium Lamp with current regulated to $\pm 0.03\%$ and with a drift of less than $\pm 0.5\%$ per hour. Alternately it will provide a constant potential regulated to $\pm 0.3\%$ with drift of less than 0.1% per hour. The ripple is less than 0.1% rms. The power supply will operate satisfactorily with an input potential of 108 to 128 Volts AC and an input frequency from 50 to 60 Hz. The adapter unit is a cast aluminum box with a hinged cover. It forms a bridge between the monochromator and the lamphouse and provides the proper optical spacing to match the focal ratio and the focusing requirements. It also serves as a holder for filters and other optical components and provides light shielding. The lamp house has conveniently located controls for centering the lamp with respect to the optical train.



Bausch & Lomb high intensity grating monochromators— a totally new design concept

These new models of novel design will enable you to get accurate, reproducible data quickly and conveniently through:

high intensity—With improved sources and efficient optical design.

high linear dispersion—With B&L Certified-Precision Gratings.

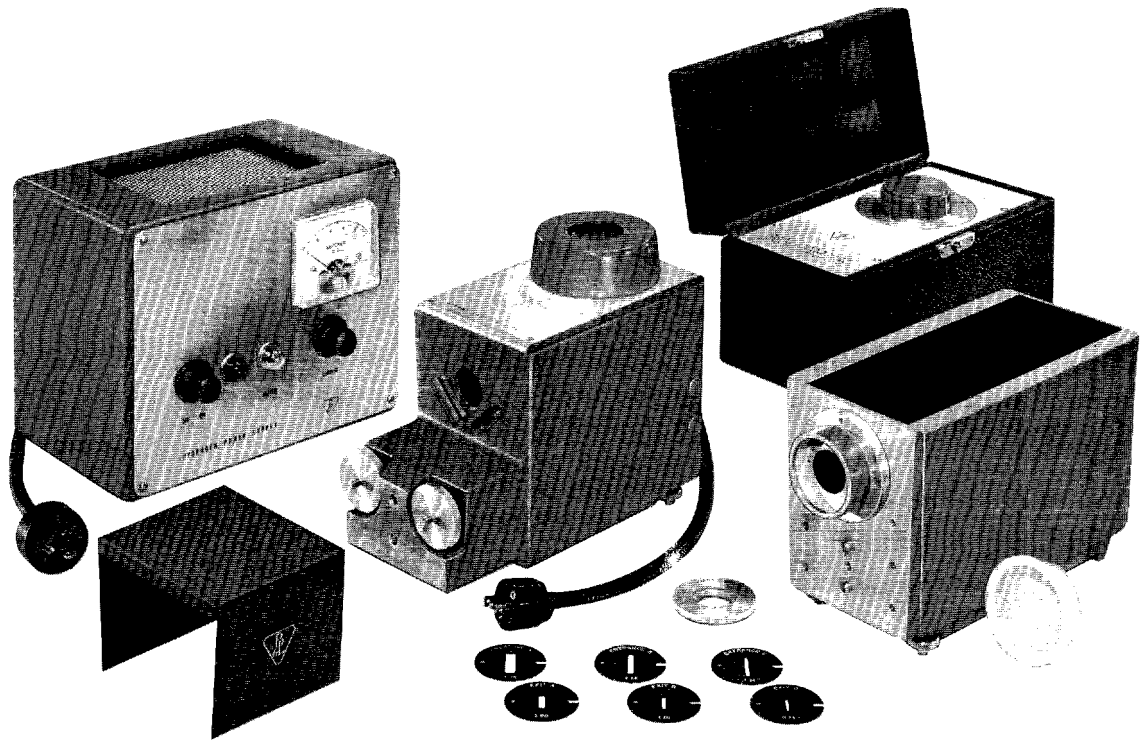
low scattered light—Higher efficiency and purity with specially designed illuminating systems.

long range—200nm to 3.2 microns by use of several gratings and appropriate sources.

versatility—"Building Block" design satisfies present needs and future expansion through choice of gratings and sources. Combines conveniently with other equipment.

compactness—Space saving and portability through small size and lightweight construction.

low price—The most complete equipment at lowest cost.



to precisely fit your needs . . .
present and future

The building block design of this instrument permits you to choose exactly the equipment you need to satisfy present requirements, with a minimum investment.

You can purchase and easily interchange additional gratings and sources whenever the need arises.

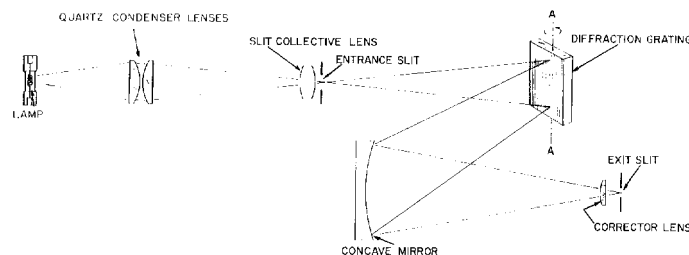
The High Intensity Monochromator consists basically of three component parts:

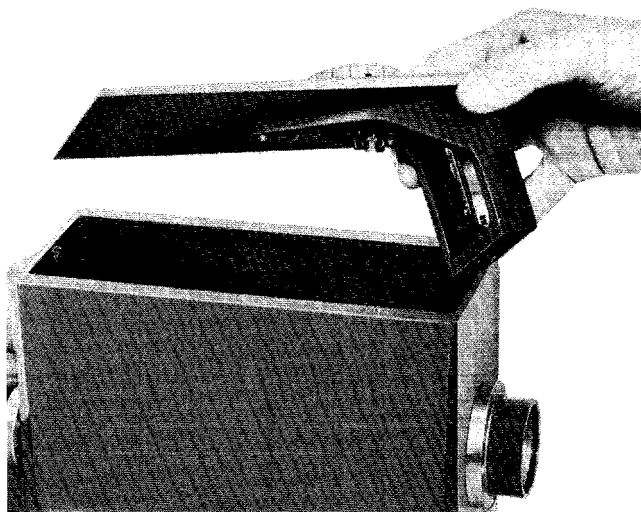
1. The monochromator unit, including fixed or variable slits.
2. The cover-grating assembly—choice of 5 assemblies, each covering a section of the total range.
3. The illuminating unit—6 to choose from: Deuterium Arc (air-cooled type), Tungsten-Halide, Tungsten Ribbon Filament, High Pressure Mercury, Super Pressure Mercury, and Xenon Arc. All are supplied with appropriate optical condenser systems and power units.

optical system

The diagram above illustrates the operation of the tungsten illumination optical system. Light originating from a source passes through a condenser system, and forms an image of the source on the entrance slit. A collector lens in front of the entrance slit collects the incident light and creates a uniformly illuminating bundle inside the monochromator. The light is then incident on the plane diffraction grating where it is angularly dispersed according to

wavelength. The grating is rotatable about the axis A-A to permit direction of a pre-determined wavelength along the central axis, in the plane formed by the two slits. The light is next collected by the concave mirror and, after passing through a fused silica aberration corrector lens, forms an image of the entrance slit on the exit slit. The optical system is of the non-collimated type, providing an exit beam cone of $f/3.5$.





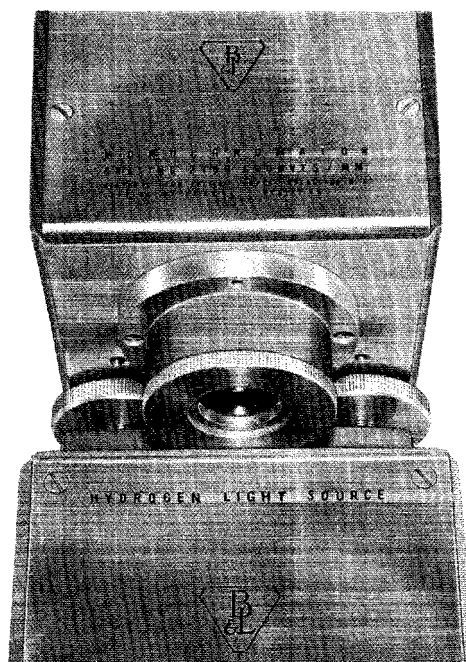
wide range . . . with five complete grating assemblies

A wide range from 200nm to 3.2 microns is obtained by a series of readily interchangeable gratings. Each is a complete, easily handled unit. The cover plate for the monochromator has the grating and rotating mechanism attached to its underside, and an actuating knob and circular wavelength scale on the top. You simply dial the desired wavelength in the range provided by a specific grating. Dispersion is linear. All grating assemblies are pre-calibrated for immediate use, and wavelength settings are reproducible. To protect it against dust and damage when not in use, a sturdy, attractive, leatherette-covered case is supplied with each assembly.

The appropriate light source should be ordered for the particular spectral range required, along with the selected grating.

recommended for uv microscopy and photomicrography

The Model 5 Monochromator (cat. No. 33-86-26-07) has been designed for use in UV Microscopy and Photomicrography. The instrument is supplied with a 1200 groove/mm grating having a blaze wavelength of approximately 200nm. Operation is over a wavelength range of

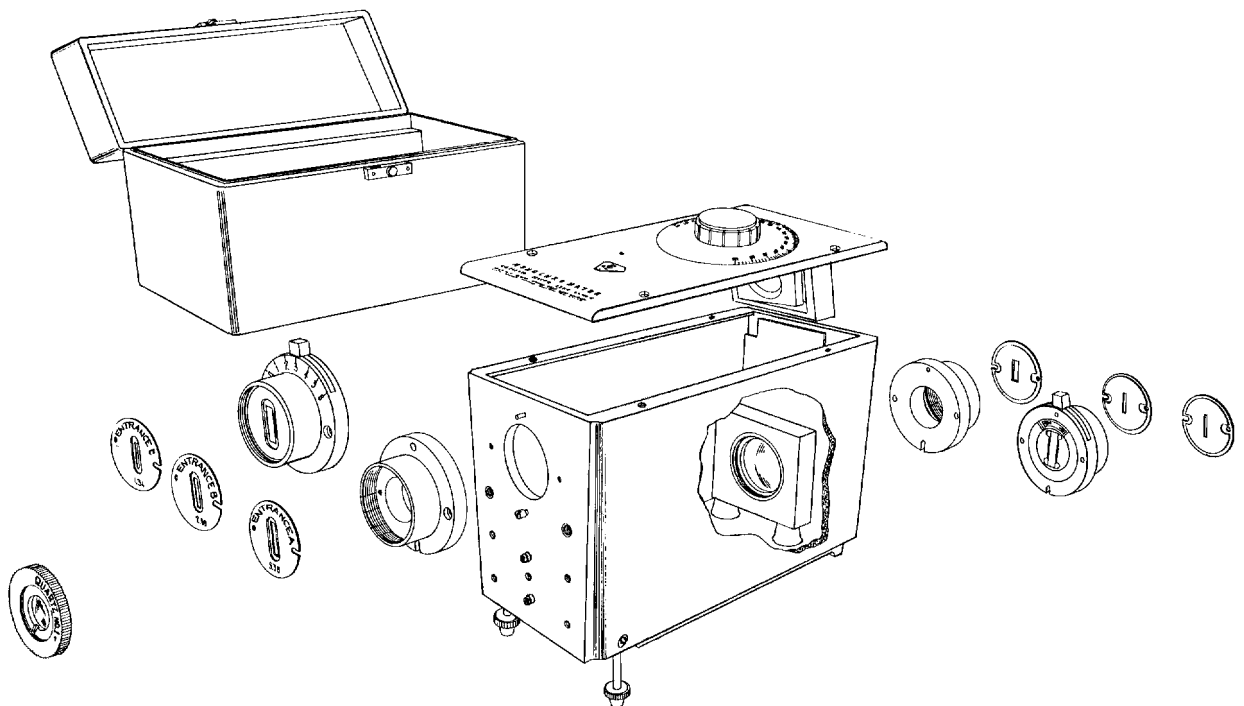


200nm-700nm. This permits use of the visible spectrum for alignment purposes while still maintaining optimum performance in the UV. The source selected for use with the Model 5 Monochromator is a High Pressure Mercury Source with 100W lamp, fused silica condensor system and the No. 2 Silica Collector Lens.

Illuminating units are quickly connected to the monochromator unit, in precise alignment, by dowels and large diameter, knurled clamping screws. A light shield is provided between the source housing and the Monochromator, eliminating entrance of extraneous light and dust.

high intensity . . . high dispersion . . . low scattered light

Results of studies using monochromatic light will be achieved with much greater accuracy and convenience because of the high levels of illumination, dispersion and purity provided by new high intensity sources, B&L Certified-Precision gratings, and a unique optical system employing only two reflecting surfaces instead of the usual four. In addition to minimizing light loss, which is especially important in the UV, the use of fewer reflecting surfaces contributes to simplicity of design with a more compact unit, lower cost and less maintenance.



easily interchangeable slits

To permit convenient matching of slit to application, both fixed and variable slits are available. The fixed slits insure reproducibility of width. They are metal discs with the slit cut into them and are easily attached to the slit mount without need for further adjustment.

The variable slits are available as an accessory or as a substitute for the fixed slits on listed equipment. These are supplied in a mount with index and scale graduated in 1mm divisions.

Entrance and exit slits are at opposite ends of the monochromator. The result is greater freedom in the

working area around the exit beam end, and comparative isolation of the illuminated area from the heat and extraneous radiation emitted by the source. Additional benefits of this design include greater convenience in operation with other equipment, such as photo-multiplier devices.

Due to the asymmetrical positioning of the focusing element (concave mirror) between the entrance and exit slits, demagnification occurs, so that the dimensions for the entrance slit are larger than those for the exit slit. Fixed slit discs are labeled as to their widths. The discs are paired and marked alphabetically so that there can be no error in using matched pairs.

size and mass

Spectral Region	Range	Blaze	Dispersion nm/mm	Scattered Light (Typical)	Instrument Blaze Efficiency (Typical)	UNIT	LENGTH	WIDTH	HEIGHT	MASS
UV	200-400nm	250nm	3.2	0.3%	30%	Monochromator				
Visible	350-800nm	500nm	6.4	0.05%	55%	Grating Assembly	20"	4 1/4"	7 1/2"	13 lbs.
Lower IR (No. 1)	7-1.6 microns	1.0 micron	12.8	0.1%	57%	and Source Housing	51 cm	12 cm	19 cm	6 kg.
Upper IR (No. 2)	1.4-3.2 microns	2.0 microns	25.0	0.2%	57%	Power Source for Deuterium	8 3/4"	6 1/2"	7 1/2"	10.5 lbs.
UV-Visible	200-700nm	220nm	7.4	0.2%	40%		22 cm	17 cm	19 cm	5 kg.
WAVELENGTH SCALE GRADUATION DATA						Power Source for SP-200 (Mercury)	8 3/4"	6 1/2"	7 1/2"	26 lbs.
UV Grating-- 2nm/Scale Division			IR #2 Grating-- 20nm/Scale Division				22 cm	17 cm	19 cm	12 kg.
Visible Grating-- 5nm/Scale Division			UV Visible Grating-- 5nm/Scale Division			Power Source for HP-100 (Mercury)	8 3/4"	6 1/2"	7 1/2"	16 lbs.
IR #1 Grating-- 10nm/Scale Division			Scale divisions are readable to 1/4 Division				22 cm	17 cm	19 cm	7 kg.
						Power Source for Xenon	15"	9 1/4"	7 1/4"	45 lbs.
							38 cm	24 cm	19 cm	20 kg.

SLITS: Fixed slit discs are labeled as to their width, and are paired and marked alphabetically for matching. Slit widths are:

1. Entrance C 1.34mm Exit C 0.75mm
 2. Entrance B 2.68mm Exit B 1.50mm
 3. Entrance A 5.36mm Exit A 3.00mm
- The variable slit is variable over a range of 0.0 to 6.0mm and the scale is graduated at 0.1mm intervals. The height of both types of slit is: Entrance 20mm; Exit 11.2mm.

general features

For ease and convenience in accurately directing the exit beam to a specimen, microscope or similar equipment, adjustable screw-type legs are provided.

A holder at the entrance slit accepts filters, when needed to eliminate unwanted orders of spectra.

The instrument is modernly trim and compact. Bench space required, exclusive of the power supply, is approximately 20"x4 1/2" and weight is only 13 lbs. The smooth two-tone finish of dark gray and buffed aluminum harmonizes with any laboratory color scheme.

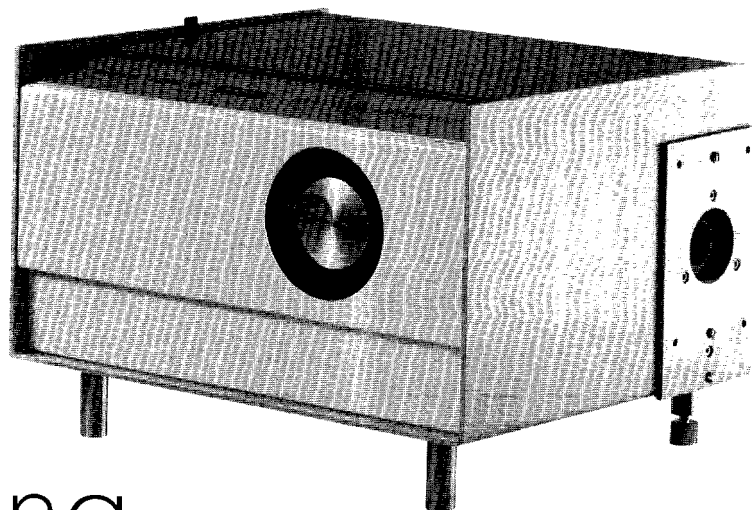
achromatic condenser lens

This Condenser Lens can be used with all B&L Monochromators—250mm, 500mm and High Intensity. It is recommended for use in applications requiring an achromatic image of the slit or where a long working distance is

required, as in microscopy, or in combination with other equipments. The condenser lens is a five element crystal quartz-fluorite focusable lens, mounted in a draw tube containing an iris diaphragm. The free aperture at the entrance is 8mm and at the exit slit variable from 1 to 25.4mm. The lens corrects for both spherical and chromatic aberrations, as well as providing an extremely long working distance. It forms an achromatic image of the slit anywhere from 26cm to infinity from the monochromator housing.

special monochromators

In addition to our standard line of monochromators, we can make up special instruments that will be tailored to your specific requirements. Just let us know what you want to do and we will be happy to quote on developing an instrument for your use.



double grating monochromator

top efficiency and versatility

This new addition to the Bausch & Lomb line of monochromators provides many of the advantages of a double monochromator at a fraction of the cost. Two *Certified-Precision* gratings are incorporated in a compact unit, assuring high dispersion in a short path length and reducing stray light to a minimum.

The design of the instrument permits ready incorporation into virtually any system the user wishes to construct. Seven light sources and a wide selection of lenses and other accessories are available for quick attachment, to make this instrument the most versatile monochromator obtainable.

Identical mounting plates on both left and right sides and a reversible optical system permit interchangeable use of the entrance and exit positions. Light sources and accessories can be mounted on either side.

Wavelength range is 190nm-825nm and the lower range can be extended to 180nm by purging with dry nitrogen through the inlet provided at the rear of the instrument. A rotatable knob conveniently located on the front panel permits quick selection of the desired wavelength. The selected wavelength shows through a window in the front bezel plate. The plate is easily removable to permit wavelength calibration to a high degree of accuracy.

quickly selected slit widths

To assure the utmost precision in slit widths, the instrument is provided with three fixed slits which give a band-pass of 0.2nm, 0.5nm and 2.0nm.

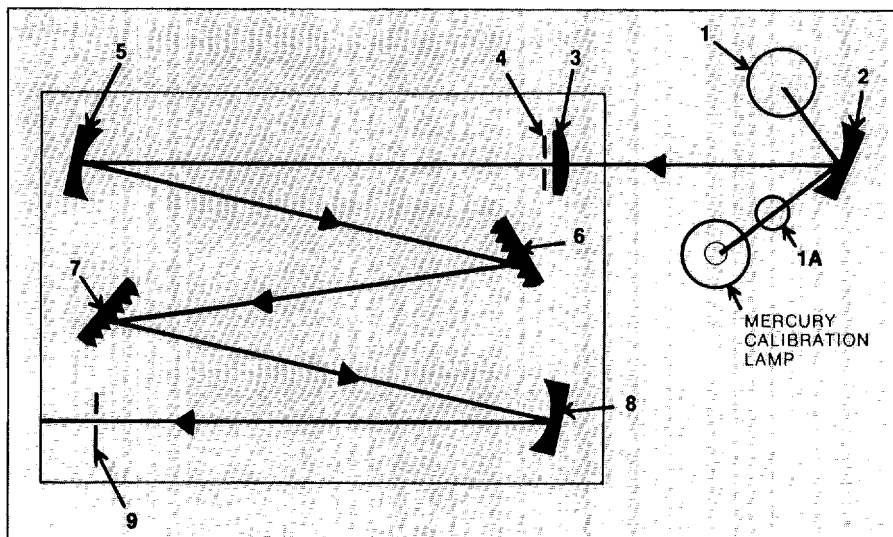
A single lever control selects both entrance and exit slits simultaneously by a ganged mechanism. Slit height is 10mm.

precision optical system

Modified Czerny-Turner, double-grating. The two 1200 grooves/mm plane reflection gratings, which are used in wide wavelength coverage but yet are optimized for the 200nm region. Both have a free aperture of 25mm diameter and an efficiency greater than 60% at 253.7nm.

motor drive for wavelength scanning

This optional accessory attaches to the monochromator, without tools, simply by depressing a lever. Driving speeds are 5, 25, and 125nm/min., with forward and reverse slew speed (500nm/min.) plus a neutral position.



The beam from a light source (1 or 1A) depending on the rotation of the condensing mirror (2) is focused on the entrance slit (4) by the slit collective lens (3). The beam then passes through to the collimating mirror (5) and is reflected to the first reflectance grating (6), where it is dispersed, then to a second reflectance grating (7) where it is further dispersed. The twice dispersed beam is reflected from the second collimating mirror (8) and passes through the exit slit (9).

accessories

extendable lens tube

This accessory consists of two aluminum tubes which are threaded on both ends. One tube is approximately twice the length of the other. They are designed primarily for use with the Silica-Fluorite Focusing Lens and work as follows: When the lens is screwed into the short tube it provides a collimated beam; when the two tubes are screwed together it provides a 1:1 slit image, and when it is used with the long tube alone it gives an intermediate image. The tubes can also be used with any of the collective lenses to give a wide variety of imaging options.

silica-fluorite focusing lens

This is a fused Silica-Fluorite triplet installed in a mount. It is achromatized over the 200 to 800nm wavelength range. Optimum performance is achieved when used 1:1;

at f/10 aperture, however it gives good achromatization for collimation and intermediate imaging positions.

general purpose lenses

No additional lens is essential to the basic operation of the Dual Grating Monochromator. However, when attached to the slit plate at the exit, these lenses provide various sized circular images of the aperture. When used in the various lens tubes they provide an image of the rectangular exit slit at various locations. Choice of lens depends on application. There are five lenses: Fused Silica-39mm focal length, Fused Silica-66mm, Fused Silica-86mm, Fused Silica-152mm, and Fluorite-Silica-Fluorite-97mm.

photomultiplier-phototube housing

This optional Photomultiplier Detector has electrical connections to permit use with conventional High Voltage Power Supplies and Microammeters.

specifications of the double grating monochromator

Mounting: Modified Czerny-Turner double grating

Reciprocal Linear Dispersion: 1.5nm/mm

Aperture Ratio: f/10

Focal Length: 250mm

Wavelength Readout: Digital Counter

Wavelength Range: 190* to 825nm.

*Lower wavelength range can be extended to 180nm by purging with dry nitrogen.

Wavelength Accuracy: Can be set to better than $\pm .1$ nm using wavelength calibration sources.

Gratings: Two gratings in tandem with:

- Efficiency—greater than 60% at 253.7nm
- Grooves/mm—1200
- Free Aperture—25mm diameter
- Blaze—broad blaze for wide wavelength coverage optimized for 200nm region.

Slits: Fixed variable type providing: 0.2, 0.5, and 2.0nm bandpass (Note: 0.2nm slits are curved). Slits are mechanically coupled with a single detented lever control. Slit height is 10mm.

Stray Light: Less than .001% at 313nm, and Less than .01% at 254nm using a high pressure mercury source.

Size and mass

Length—13"
Width—10 $\frac{3}{4}$ "

Height—9"
Weight—23 lbs.

ordering information

Catalog Number	Description	Catalog Number	Description
	250mm grating monochromators		light sources for separate purchase
33-86-40	250mm Grating Monochromator; 600 groove/mm, 300nm blaze; no light source		For use with 250mm and 50mm Grating Monochromators
33-86-40-01	250mm Grating Monochromator; 600 groove/mm, 300nm blaze; with High Pressure Mercury Light Source (33-86-42-01)	33-86-42-01	High Pressure Mercury Light Source; including ballast
33-86-40-02	250mm Grating Monochromator; 600 groove/mm, 300nm blaze; with Tungsten Light Source (33-86-44-01)	33-86-44-01	Tungsten Light Source, including step down transformer
33-86-40-03	250mm Grating Monochromator; 600 groove/mm, 300nm blaze; with Deuterium Light Source (33-86-47-01)	33-86-62-01	Xenon Light Source, collector lens and power supply
		33-86-65-01	Deuterium Light Source, collector lens and power supply
			NOTE: Xenon Light Source can be supplied for use with 250mm and 500mm Models on Special order.
	500mm grating monochromators*		high intensity monochromators
33-86-45-38	500mm Model; 600 groove/mm; 300nm blaze; with Deuterium Light Source	33-86-25-01	High Intensity, Model 1, with UV Grating and case, fixed slits, Deuterium Source and Collector Lens (Fused Silica #1)
33-86-45-39	500mm Model; 1200 groove/mm; 300nm blaze; with Deuterium Light Source	33-86-25-02	High Intensity Model 2, with Visible Grating and Case. Fixed slits, Tungsten-Halide Source and Collector Lens (Fused Silica #1)
33-86-45-48	500 Model; 600 groove/mm; 300nm blaze; with High Pressure Mercury Light Source	33-86-25-03	High Intensity Model 3, with IR #1 Grating and Case. Fixed slits, Tungsten-Halide Source and Collector Lens (Fused Silica #1)
33-86-45-49	500mm Model; 1200 groove/mm; 300nm blaze; with High Pressure Mercury Light Source	33-86-25-04	High Intensity Model 4, with IR #2 Grating and Case. Fixed slits, Tungsten-Halide Source and Collector Lens (Fused Silica #1)
33-86-50	Grating; 300 groove/mm; 1 micrometer blaze with Drum and Vernier	33-86-26-07	High Intensity, Model 5, with UV-Visible Grating and Case. Variable slits, High Pressure Mercury Source and Collector Lens (Fused Silica #2)
33-86-45-58	300mm Model; 600 groove/mm; 300nm blaze; with Tungsten Light Source		(This model is recommended for broad spectral coverage and UV Microscopy where a high order of resolution in the visible region is not required)
33-86-45-59	500mm Model; 1200 groove/mm; 300nm blaze; with Tungsten Light Source		grating assemblies
	gratings		For High Intensity Models
	A number of gratings, other than those supplied as standard equipment are available for use with 250mm and 500mm Monochromators. These are 300 groove/mm, 600 groove/mm and 1200/mm with blaze angles from 300nm to 2.0um. Write for quotations.	33-86-01	UV Grating and Case
		33-86-03	IR #1 Grating and Case
		33-86-04	IR #2 Grating and Case
		33-86-07	UV-Visible Grating and Case

July, 1969

Bausch & Lomb GRATING MONOCHROMATORS

Catalog Number	DESCRIPTION	Suggested List Price	Catalog Number	DESCRIPTION	Suggested List Price
250MM GRATING MONOCHROMATORS			GRATINGS		
33-86-40	250mm Grating Monochromator; 600 groove/mm, 300nm blaze; no light source	\$1435.00	A number of gratings, other than those supplied as standard equipment are available for use with the 250mm and 500mm Monochromators. These are 300 groove/mm, 600 groove/mm and 1200 groove/mm with blaze angles from 300nm to 2.0 micrometers.		
33-86-40-01	250mm Grating Monochromator; 600 groove/mm, 300nm blaze; with High Pressure Mercury Light Source	1735.00	Write for quotation.		
33-86-40-02	250mm Grating Monochromator; 600 groove/mm, 300nm blaze; with Tungsten Light Source	1585.00	HIGH INTENSITY MONOCHROMATORS		
33-86-40-03	250mm Grating Monochromator; 600 groove/mm, 300nm blaze; with Deuterium Light Source	2205.00	33-86-25	Monochromator Housing for 33-86-01, 33-86-02, 33-86-03, 33-86-04.	\$ 245.00
500MM GRATING MONOCHROMATORS*			33-86-25-01	High Intensity, Model 1, with UV Grating and case, fixed slits, Deuterium Source and Collector Lens (Quartz No. 1)	1350.00
33-86-45-38	500mm Model; 600 groove/mm; 300nm blaze; with Deuterium Light Source	2880.00	33-86-25-02	High Intensity, Model 2, with Visible Grating and case. Fixed slits, Tungsten-Halide Source and Collector Lens (Quartz No. 1)	980.00
33-86-45-39	500mm Model; 1200 groove/mm; 300nm blaze; with Deuterium Light Source	3410.00	33-86-25-03	High Intensity, Model 3, with IR No. 1 Grating and case. Fixed slits, Tungsten-Halide Source and Collector Lens (Quartz No. 1)	980.00
33-86-45-48	500mm Model; 600 groove/mm; 300nm blaze; with High Pressure Mercury Light Source	2310.00	33-86-25-04	High Intensity, Model 4, with IR No. 2 Grating and case. Fixed slits, Tungsten-Halide Source and Collector Lens (Quartz No. 1)	980.00
33-86-45-49	500mm Model; 1200 groove/mm; 300nm blaze; with High Pressure Mercury Light Source	2840.00	33-86-26	Monochromator Housing for 33-86-07.	245.00
33-86-50	Grating; 300 groove/mm; 1 micrometer blaze with Drum and Vernier.	685.00	33-86-26-07	High Intensity, Model 5, with UV-Visible Grating and case. Variable slits, High Pressure Mercury Source and Collector Lens (Quartz No. 2)	1585.00
33-86-45-58	500mm Model; 600 groove/mm; 300nm blaze; with Tungsten Light Source	2190.00	(This model is recommended for broad spectral coverage and UV Microscopy where a high order of resolution in the visible region is not required.)		
33-86-45-59	500mm Model; 1200 groove/mm; 300nm blaze; with Tungsten Light Source	2720.00	33-86-28	Corrector Lens for 33-86-07 grating used in 33-86-25 Housing	50.00
LIGHT SOURCES			GRATING ASSEMBLIES		
FOR SEPARATE PURCHASE			For High Intensity Models		
For use with 250mm and 500mm Grating Monochromators			33-86-01	UV Grating and Case	400.00
33-86-42-01	High Pressure Mercury Light Source; including ballast	300.00	33-86-02	Visible Grating and Case	400.00
33-86-44-01	Tungsten Ribbon Filament Light Source, including step-down transformer	150.00	33-86-03	IR No. 1 Grating and Case	400.00
33-86-65-01	Deuterium Light Source with Collector Lens	770.00	33-86-03	IR No. 2 Grating and Case	400.00
33-86-62-01	Xenon Light Source	987.50	33-86-07	UV-Visible Grating and Case	550.00

Catalog
Number

Approved For Release 2003/08/05 : CIA-RDP78B05171A000300010034-9
DESCRIPTION

Suggested
List Price

Catalog
Number

DESCRIPTION

Suggested
List Price

LIGHT SOURCES FOR SEPARATE PURCHASE

For use with High Intensity Models

33-86-39-01	Tungsten-Halide Source, including step-down transformer and Collector Lens . . .	\$ 290.00
33-86-35-01	Deuterium Light Source, power supply and Collector Lens.	690.00
33-86-36-01	Super pressure Mercury Source, power supply and Collector Lens.	600.00
33-86-38-01	High Pressure Mercury Source, power supply and Collector Lens.	600.00
33-86-20-01	Xenon Light Source, power supply and Collector Lens	900.00

SLITS AND COLLECTIVE LENSES

For High Intensity Models

33-86-31	Variable Slits, mounted, 1 pair	210.00
33-86-32	Fixed Slits, mounted, 3 pair	60.00
33-86-29	Collector Lens, Quartz No. 2 for High Pressure Mercury Source	35.00
33-86-34	Collector Lens, Quartz No. 1 for all sources except High Pressure Mercury Source	35.00

*M.C.P. -- Manufacturer's Current Price

Prices are subject to change without notice. Excise taxes or other governmental charges will be added wherever applicable.

REPLACEMENT LAMPS

For 250mm, 500mm and High Intensity Models

*33-33-02	Super Pressure Mercury Lamp (SP-200) 200 watts for 33-86-36-01 Light Source. . .	\$ 45.00M.C.P.
*33-33-15	Tungsten-Halide Lamp, 45W for 33-86-39-01 Light Source.	9.15M.C.P.
*33-33-30	Deuterium Lamp, 20 Watts for 33-86-35-01 and 33-86-65-01 Light Source	120.00M.C.P.
*33-33-38	Tungsten Ribbon Filament Lamp, 6 volts, 18 amps. for 33-86-44-01 Light Source . .	11.00M.C.P.
*33-33-42	High Pressure Mercury Lamp (HP-100) 100 Watts for 33-86-38-01 or 33-86-42-01 Light Source.	65.00M.C.P.
*33-33-20	Xenon Lamp, 150 Watts for 33-86-20-01 Light Source.	85.00M.C.P.

ACCESSORY

For use with 250mm, 500mm and High Intensity Models

33-86-53	Achromatic Condenser Lens.	310.00
----------	------------------------------------	--------

BAUSCH & LOMB



ROCHESTER, NEW YORK 14602

ANALYTICAL SYSTEMS DIVISION

Catalog Number	Description	Catalog Number	Description
	light sources for separate purchase For use with High Intensity Models	33-86-35	Deuterium Light Source and Power Supply
33-86-39-01	Tungsten-Halide Source, including step-down transformer and collector lens	33-86-36	Super Pressure Mercury Source and Power Supply
33-86-35-01	Deuterium Light Source, power supply and collector lens	33-86-38	High Pressure Mercury Source and Power Supply
33-86-36-01	Super pressure Mercury Source, power supply and collector lens	33-86-39	Tungsten-Halide Source and Power Supply
33-86-38-01	High Pressure Mercury Source, power supply and collector lens		
33-86-20-01	Xenon Light Source, power supply and collector lens		accessory lenses
		33-86-29	39mm focal length
		33-86-72	66mm focal length
		33-86-34	86mm focal length
		33-86-63	152mm focal length
		33-86-69	197mm focal length
	slits and collective lenses For High Intensity Models		
33-86-31	Variable Slits, mounted, 1 pair		
33-86-32	Fixed Slits, mounted, 3 pair		
33-86-29	Collector Lens, Fused Silica #2 for High Pressure Mercury Source		replacement lamps
33-86-34	Collector Lens, Fused Silica #1 for all sources except High Pressure Mercury Source		For 250mm, 500mm High Intensity Models, & Double Grating Models
		33-33-02	Super Pressure Mercury Lamp (SP-200) 200 watts for 33-86-36-01 Light Source
		33-33-15	Tungsten-Halide Lamp, 45w for 33-86-39-01 Light Source
33-86-66-01	double grating monochromator Double Grating Monochromator, Two 1200 grooves/mm gratings, broad blaze for wide wavelength coverage, optimized for 200nm region, without light source	33-33-30	Deuterium Lamp, 20 watts for 33-86-35-01 and 33-86-47-01 Light Source
33-86-70	Telescoping lens tube	33-33-38	Tungsten Ribbon Filament Lamp, 6 volts, 18 amps. for 33-86-44-01 Light Source
33-86-67	Wavelength drive, 60 Hz, 115V.	33-33-42	High Pressure Mercury Lamp (HP-100) 100 watts for 33-86-38-01 or 33-86-42-01 Light Source
		33-33-24	Xenon Lamp, 150 watts for 33-86-20-01 Light Source
	light sources for separate purchase For use with Double Grating Monochromator		
33-86-68-01	Dual Lamphouse (UV-VIS) Power Supply and adapter		accessory
33-86-20	Xenon Light Source and Power Supply		For use with 250mm, 500mm and High Intensity Models
		33-86-53	Achromatic Condenser Lens

ROCHESTER HEADQUARTERS

Bausch & Lomb, Inc.
Analytical Systems Division
820 Linden Avenue
Rochester, N.Y. 14625
(716) 385-1000

NEW YORK—NEW JERSEY

Bausch & Lomb, Inc.
Analytical Systems Division
Room 404
100 Menlo Park
Edison, New Jersey 08817
(201) 548-9411

BOSTON

Bausch & Lomb, Inc.
Analytical Systems Division
565 Commonwealth Avenue
Boston, Massachusetts 02215
(617) 262-6100

WASHINGTON

Bausch & Lomb, Inc.
Analytical Systems Division
Suite 304, Executive Building
7100 Baltimore Avenue
College Park, Maryland 20740
(301) 779-1230

PHILADELPHIA

Bausch & Lomb, Inc.
Analytical Systems Division
349 Lancaster Avenue
Haverford, Pennsylvania 19041
(215) MI 9-6663

HOUSTON

Bausch & Lomb, Inc.
Analytical Systems Division
Suite 240
6400 West Park Drive
West Park Plaza
Houston, Texas 77027
(713) 781-0276

ATLANTA

Bausch & Lomb, Inc.
Analytical Systems Division
3355 Lenox Road N.E.
Suite 860
Atlanta, Georgia 30326
(404) 261-5021

CHICAGO

Bausch & Lomb, Inc.
Analytical Systems Division
899 Skokie Boulevard
Northbrook, Illinois 60062
(312) 498-0400

DETROIT

Bausch & Lomb, Inc.
Analytical Systems Division
20200 W. Outer Drive
Dearborn, Michigan 48124
(313) 565-6628

SAN FRANCISCO

Bausch & Lomb, Inc.
Analytical Systems Division
780 West Grand Avenue
Oakland, California 94612
(415) 836-2366

LOS ANGELES

Bausch & Lomb, Inc.
Analytical Systems Division
17452 Irvine Boulevard
Tustin, California 92680
(714) 544-0830

TORONTO

Bausch & Lomb—Canada
Analytical Systems Division
1790 Birchmont Road
Scarborough, Ontario
(416) 291-7911

MONTREAL, P.Q.

Bausch & Lomb—Canada
Analytical Systems Division
110 Cremazie West, Suite 707
Montreal 11, Quebec
(514) 381-8519

OTTAWA

Bausch & Lomb—Canada
Analytical Systems Division
227 Laurier Ave. West
Ottawa, Ontario
(613) 232-1544

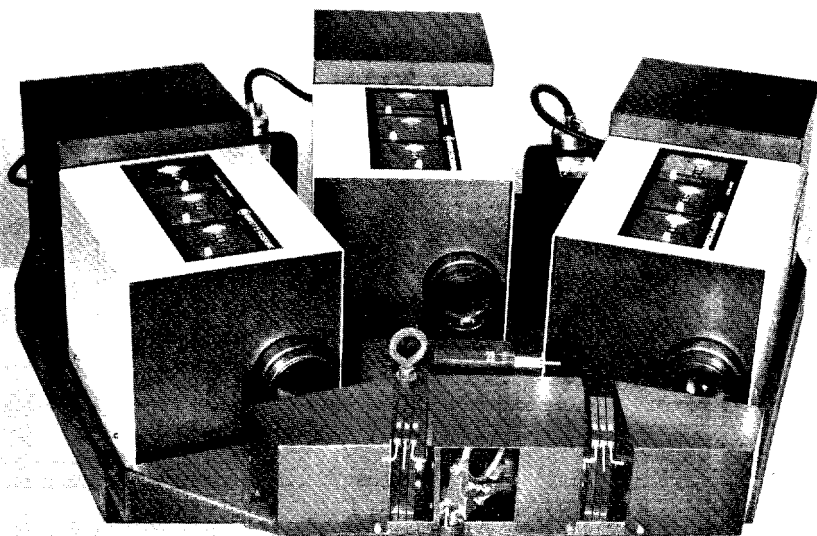
BAUSCH & LOMB 
ANALYTICAL SYSTEMS DIVISION

ROCHESTER, NEW YORK 14625

Analytical Systems Division products
are available in most countries.

For information, write:

Bausch & Lomb, Inc.
Analytical Systems Division
International Marketing
820 Linden Avenue
Rochester, N.Y. 14625



VARIABLE CONTRAST
ILLUMINATOR

BAUSCH & LOMB

The Variable Contrast Illuminator tests the performance of aerial lenses in respect to color, contrast, and flare (background light). It simulates the apparent sizes, colors and contrasts of actual ground targets encountered in aerial photography.

Contrast ratios are 1000 to 1 when a dark background is used; 30 to 1 when using a light background.

The basic instrument consists of:

- 3 illumination units
- a target and
- a pellicle (beamsplitter)

THE ILLUMINATOR

Each illuminator is capable of producing red, blue and green; and any other color which can be produced by a combination of these three primaries. The colors are individually controlled by knobs on the top of each illuminator. Each illuminator also has a 3-position switch for regulating intensity.

The left-hand illuminator is designated "target reflectance". Its output is reflected from the pellicle to the target, and returned through the pellicle. It provides the color which simulates an area surrounding a ground target.

The center illuminator is designated "target transmittance". Its output is directed through the target, through the pellicle, and to the lens to be tested. It provides the color which simulates the ground target.

The right-hand, or "flare" illuminator simulates the haze or background light which would be encountered in photographing from a reconnaissance aircraft. Like the other illuminators, it has a full range of color outputs.

THE TARGET

Targets are ruled on a reflecting substrate and are available in a variety of patterns including, of course, a bar type.

THE PELLICLE

The pellicle is a thin film beamsplitter which has properties of equal reflectance and equal transmittance. Its function is to direct the light rays from the illuminators to the photographic lens.

HOW THE CONTRAST ILLUMINATOR WORKS

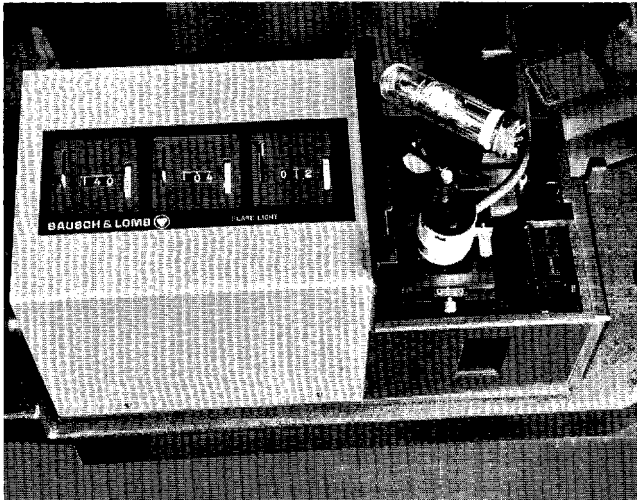
Suppose, for example, that you wished to test a particular lens for photography of dark red buildings, surrounded by green countryside through a blue haze.

First step is to set the "target transmittance" illuminator so that its output is the shade and intensity of red you desire. This is done by rotating the color control knobs and setting the intensity on the illuminator.

The output of the "target reflectance" illuminator is then set for a selected green. And, finally, the "flare" illuminator is set for blue.

(OVER)

You have now simulated the photographic situation. By using a target resembling the size and shape of your actual ground target, you have set up a testing procedure as close to actual conditions as possible.



Flare light illuminator and color controls

APPLICATIONS

The Variable Contrast Illuminator can be used equally well with black and white, and color film. Any type of photographic lens can be tested. The target of the Variable Illuminator can be placed in the back focal plane of a collimator thus permitting the simulation of the distance from aerial lens to ground target.

SPECIFICATIONS

Height	12¾"
Width	38"
Depth	33¾"
Weight225 lbs.
Power requirements	115 volts, 60 cps, 400 watts

ORDERING INFORMATION

Price and delivery information can be obtained by writing Photogrammetric Contracts Section, Bausch & Lomb, Rochester, New York 14602.

DESIGN CHANGES

Since our products are constantly reviewed for possible improvements in design or materials, specifications may vary from those stated.

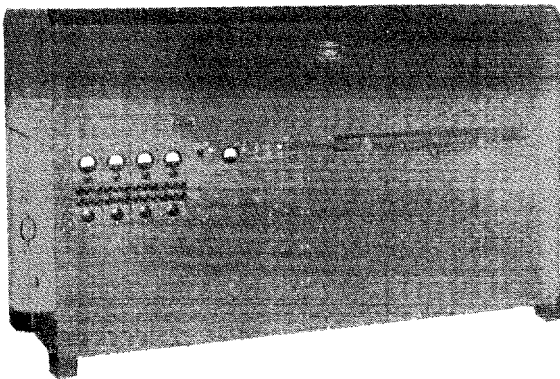
The Variable Contrast Illuminator was developed for Wright Patterson Air Force Base, Avionics Laboratory, under contract #AF33(615)-2630.

BAUSCH & LOMB  ROCHESTER, NEW YORK 14602

OUTLOOK

ENGINEERING CORPORATION

INSTRUMENTS FOR SCANNING AND PROCESSING



SCANNING COLOR SEPARATION INSTRUMENT

COLOR RECOGNITION

COLOR-RECOGNITION UNITS

CAN BE SET FOR ANY COLOR,
GIVE SIGNAL WHEN IT APPEARS.
ADJUSTABLE COLOR RESOLUTION.

FACSIMILE

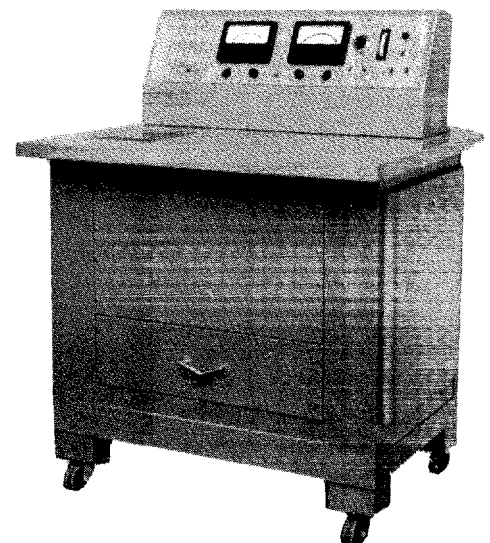
COPYING OF SINGLE COLOR

INTEGRATION

MEASUREMENT OF AREA IN ANY COLOR

SCANNING

HIGH RESOLUTION
OVER ENTIRE FIELD
HIGH POSITIONAL ACCURACY
HIGH SPEED



DARK SPOT DISCRIMINATOR AND INTEGRATOR

Special combinations for special applications. Let us help you.

OUTLOOK ENGINEERING CORPORATION

2018 MOUNT VERNON AVENUE

TE 6-0010

ALEXANDRIA, VIRGINIA

SYLVANIA

Approved For Release 2003/08/05 : CIA-RDP78B05171A000300010034-9

ENGINEERS LETTER

NO. 39-20

LIGHTING DIVISION

MAIN SUBJECT CLASSIFICATION

TO: REGIONAL & DISTRICT ENGINEERS	DATE: Apr. 24, 1969	INCANDESCENT		IODINE QUARTZ	
FROM: Don R. Johnson		FLUORESCENT	X	GRO-LUX	
MARKET APPLICATIONS ENGINEERING DEPT. LIGHTING CENTER, DANVERS, MASS.		MERCURY		MISCELLANEOUS	

SECONDARY SUBJECTS

FLUORESCENT LAMP COLOR PARAMETERS

Below you will find an up-to-date listing of the color coordinates, color temperatures and color rendering index for the most popular white fluorescent lamps. You will notice the list starts with the warmer colors and ends with the cooler color temperatures.

FLUORESCENT LAMP	CHROMATICITIES	COLOR TEMPERATURE	COLOR RENDERING INDEX
Incandescent-	X .462		
Fluorescent-	Y .416	2700°K	90
Warm White Deluxe	X .437		
	Y .398	2950°K	73
Warm White	X .434		
	Y .405	3050°K	55
White	X .408		
	Y .397	3500°K	62
Natural	X .388		
	Y .361	3700°K	81
Cool White Deluxe	X .372		
	Y .365	4100°K	86
Cool White	X .370		
	Y .378	4300°K	67
Design White	X .340		
	Y .354	5200°K	82
Daylight	X .313		
	Y .337	6500°K	79

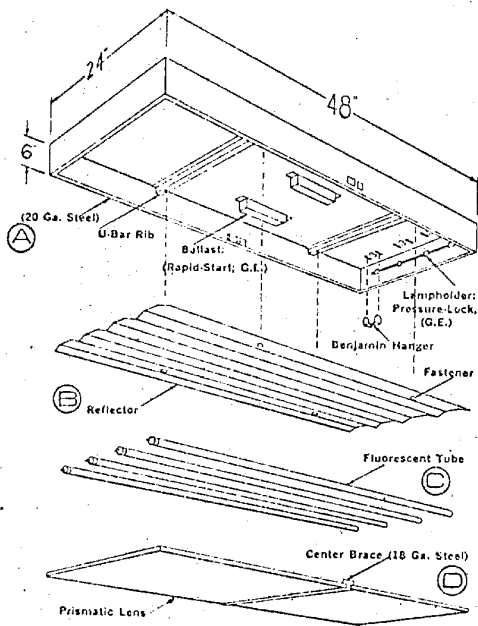
D. R. Johnson

DRJ/gab

MACBETH

PROOF-LITE®

5000K-7500K OVERHEAD LUMINAIRES



a) Shell maintains proper operating temperature for special Macbeth tubes. b) Reflector is non-UV absorbing so that UV* component is present in the fixture's irradiated light. c) Special Macbeth tubes produce proper balance of colors so that the light, when altered by the diffuser and reflector, is of correct quality. d) Diffuser of special patterned waterwhite glass for even distribution of soft, blended light.

*Ultraviolet

MECHANICAL & ELECTRICAL SPECIFICATIONS:

TUBES: 40 watt Macbeth long-life, rapid-start (see chart below).

BALLASTS: 40 watt G.E. rapid-start; high power factor (see chart below).

INPUT VOLTAGE: 120 VAC, 60 Hz; 240 VAC, 60 Hz

POWER CONSUMPTION & AIR CONDITION LOAD: See chart below.

LENS: Two panels, Pyrex No. 7740 (Corning Pattern 79) clear, prismatic glass lens.

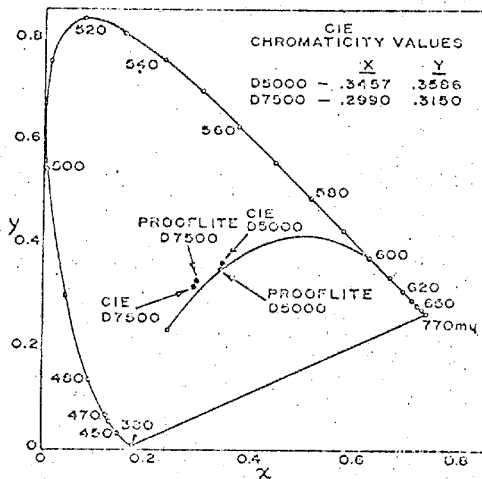
REFLECTOR: Removable special finished aluminum.

WEIGHT: See chart below.

EXTERIOR FINISH: All painted metal parts bonderized and finished with baked white polymerin.

PACKAGING: Each fixture packed complete (including tubes, glass, and Installation and Maintenance instructions) in a special shipping carton.

PERFORMANCE DATA:



PL-D75 SOURCE:

Correlated Color Temperature7500°K
Chromaticity Aim Points $x = .2990$ $y = .3150$
Color Rendering Index90 or higher (ref. Illuminant D7500)
LensSpectral transmission better than 90% over entire visible spectrum
ReflectorMinimum reflectivity of 82% over visible spectrum range

SPECIFICATION CHART

Model No.	No. of Tubes	Tube Type	No. of Ballasts	Power Watts	Total BTU's	Net Wt. (lbs.)
PL-D50-440	4	F40T12/PL50	2	184	628	57.5
PL-D50-840	8	F40T12/PL50	4	368	1256	68.0
PL-D75-440	4	F40T12/PL75	2	184	628	57.5
PL-D75-840	8	F40T12/PL75	4	368	1256	68.0
PL-D50/75 840	8	(4)F40T12/PL50 (4)F40T12/PL75	4	184	628	68.0

PL-D50 SOURCE:

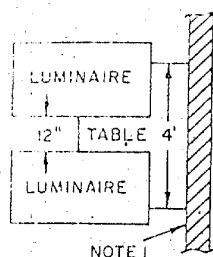
Correlated Color Temperature5000°K
Chromaticity Aim Points $x = .3457$ $y = .3586$
Color Rendering Index90 or higher (ref. Illuminant D5000)
LensSpectral transmission better than 90% over entire visible spectrum
ReflectorMinimum reflectivity of 82% over visible spectrum range

®

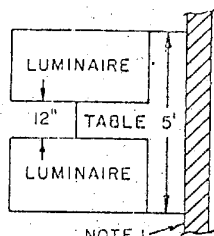
MACBETH CORPORATION • BOX 950 • NEWBURGH, N. Y. 12550

© Reg. Macbeth Corporation

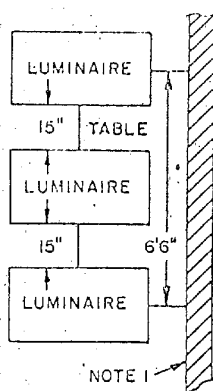
TABLE TOP DEPTH



NOTE 1



NOTE 1-



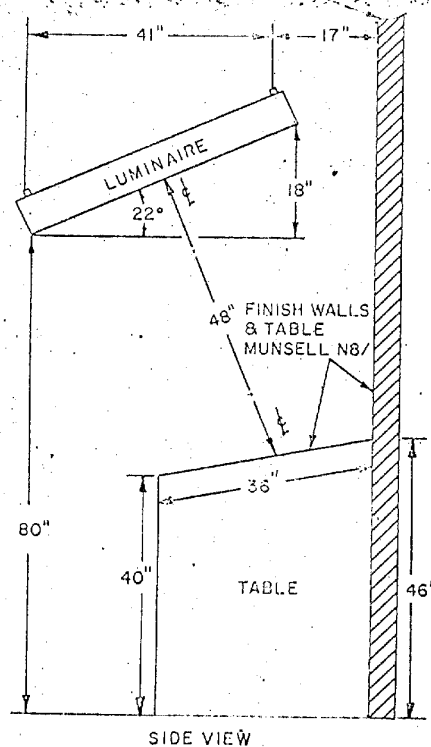
NOTE

TOP VIEWS

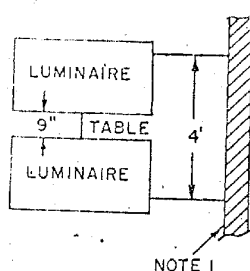
NOTES

- Viewing conditions can be enhanced by providing a neutral gray (equivalent to Munsell N8/1) background on one or more sides of the proofing table. With or without such a background, results obtained from installation arrays in this illustration conform to USA Draft Standard PH2.32 pertaining to viewing conditions for the appraisal of Color Quality and Color Uniformity.

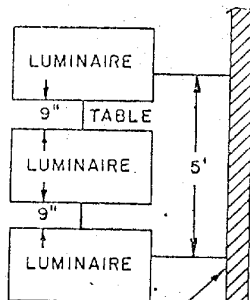
2. Filler panels used above fixtures to block outside light should be finished in a neutral gray equivalent to Munsell notation N8/.



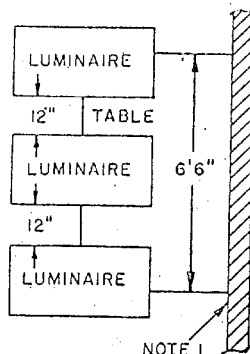
SUGGESTED INSTALLATION OVER PROOFING TABLE—
4-FT. TABLE TOP DEPTH



NOTE



NOTE 1



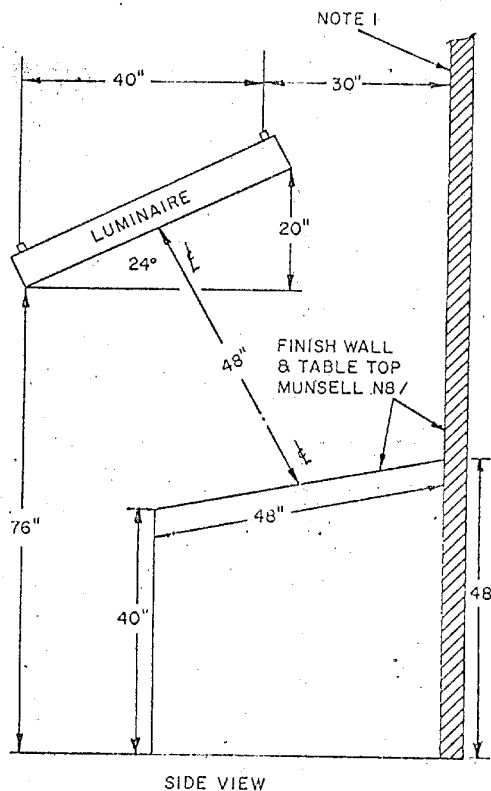
NOTE

TOP VIEWS

NOTES:

1. Viewing conditions can be enhanced by providing a neutral gray (equivalent to Munsell N8/) background on one or more sides of the proofing table. With or without such a background, results obtained from installation arrays in this illustration conform to USA Draft Standard PH2.32 pertaining to viewing conditions for the appraisal of Color Quality and Color Uniformity.

2. Filler panels used above fixtures to block outside light should be finished in a neutral gray equivalent to Munsell notation N8/



99-1
PH2.31
(Partial Revision of
PH2.23-1961)

Draft USA Standard

Direct Viewing of Photographic Color Transparencies

Approved by Board in 1969 by vote of 99-1

This standard has been approved by the cognizant USA Standards Committee for publication as a draft standard for comment and criticism. Recommended distribution of this draft standard shall not continue beyond six months from the date of publication. It is expected that following this six months period, this standard, revised as necessary, will be submitted to the United States of America Standards Institute for approval as a USA Standard. Suggestions for revision should be directed to USA Standards Committee PH2.6, Working Group VIII, c/o USA Standards Institute, 10 East 40th Street, New York, N.Y. 10016.

Published August 25, 1968
Sponsor: Photographic Standards
Board

Copyright © 1968 by the
United States of America
Standards Institute

CLID for Enclines (color)

Contents

SECTION	PAGE
Introduction	3
1. Scope	4
2. Specifications	5
2.1 Chromaticity	5
2.2 Spectral Power Distribution	5
2.3 General Color Rendering Index	5
2.4 Luminance	5
2.5 Diffusion Characteristics	5
References	6
Tables	
Table 1 Relative Spectral Emittance of Reference Illuminant D_{5000}	5
Table 2 Relative Luminous Efficiency of a Monochromatic Radiation of Wavelength λ	6
Figure 1 Chromaticity Coordinate Tolerances About Aim Point	4
Appendixes	
Appendix A General Color Rendering Index (R_a)	7
Tables	
Table A1. Spectral Reflectances of CIE Color Rendering Test Objects 1 Through 8 Used for Determining R_a	7
Table A2. CIE Color Difference Vector Magnitudes Corresponding to One-Percent Increments of R_a	8
Appendix B Definition of CIE Daylight Illuminants	10
Tables	
Table B1. Spectral Power Eigenvectors as a Function of Wavelength	10
Table B2. Illuminant D Parameters as a Function of Color Temperature	11

Working Group VIII of Subcommittee PH2.6 of the United States of America Standards Institute, which developed this standard, consisted of the following persons:

C. J. Bartleson, *Chairman*

F. R. Clapper
G. B. Keyes
C. S. McCamy

C. N. Nelson
I. J. Newman
J. P. Weiss

Draft USA Standard Direct Viewing of Photographic Color Transparencies

Introduction

The purpose of this standard is to provide specifications for illuminators for use in viewing photographic color transparencies under environmental conditions that may not be subject to control or standardization. This standard relates to the critical viewing of color transparencies. The specifications of this standard supersede those of Section 2 of USA Standard PH2.23-1961. [1]

One of the guiding principles used in the preparation of this standard is that the illuminator surface, against which a transparency is to be viewed, should appear white rather than chromatic. There are many different light sources that would be suitable for use in a color-transparency illuminator if the surround conditions or illuminator intensity could be adjusted to favor each source. However, it is not always practical to do so. Some compromise must be found that will permit the illuminator surface to appear white under the largest possible number of practical circumstances.

Some form of daylight is especially appealing as a candidate for a standard source for transparency illuminators, since it is the natural source with which human observers have most experience. Practical experience and controlled experimentation [2-6] both have shown that a general-purpose illuminator for use in existing and uncontrolled room lighting should be of daylight quality, and of an intermediate correlated color temperature, such as 5000 Kelvins, in order to maintain a satisfactory appearance of whiteness in most of the rooms in which it will be used. In the present standard, an illuminator of this type is specified for this application.

Another guiding principle, which is important in choosing the specifications of an illuminator for color transparencies, is that the illuminating surface must provide adequate amounts of energy of all frequencies that normally stimulate vision. That is, the spectral power distribution

should be sufficiently complete so as not to exhibit large differences among those broad bands of energy that normally appear red, green, and blue. The requirement of whiteness is not sufficient, for there are many spectral power distributions that will provide adequately white-appearing radiation. A certain combination of blue-appearing and monochromatic (i.e., nearly single-frequency) light, for example, will provide the desired whiteness but would be completely unsuitable for illuminating photographic color transparencies. The "color rendering" properties of such sources are said to be inadequate. For this reason, a minimum tolerance is specified for color rendering in terms of the Commission Internationale de l'Éclairage (CIE) General Color Rendering Index. [7] Computational procedures for determining the CIE General Color Rendering Index are given in Appendix A. This index is taken with respect to a specified reference, and includes the effects of any baffles, reflectors, filters, diffusers, etc, in addition to the effects of the radiating source itself. This has been done in order to avoid the possibility of degradation of color rendering properties of the illuminator by spectrally selective reflecting and transmitting media that normally are a part of practical illuminator devices.

In the same manner, the specifications for correlated color temperature, chromaticity coordinates, and luminance of the standard illuminator all are related to the illuminated surface upon which a color transparency is to be viewed.

A special problem exists when two or more illuminators are used for side by side comparisons. The desirable tolerances for difference in chromaticity and luminance are much smaller under such conditions than when illuminators are used alone. The chromaticity coordinates of two illuminator surfaces must be very nearly the same if the surfaces are to appear identical to an observer who compares them in juxtaposition, while, on the other hand, even a considerable difference may not be recognized when they are used in different places or at different times.

Studies of this problem have shown that the chromaticity tolerances required to ensure that all illuminators will have exactly the same color appearance when used side-by-side are smaller than are presently within the ability of illuminator manufacturers to provide. Accordingly, the chromaticity tolerances specified in this standard represent approximately the limit of control capabilities of fabrication according to the present state of the art. It is emphasized that the objective should be the chromaticity coordinates specified as the aim-point. Tolerances take cognizance of the design and engineering problems in attempting to achieve the objective and serve only to define a region of normal variation within which an illuminator shall be said to comply with the specifications of this standard.

1. Scope

1.1 This standard applies to the lighting conditions to be used in critical viewing of photographic color transparencies on a diffuse illuminator and relates to the surface of such an illuminator upon which the transparency is placed.

1.2 This standard does not apply to the viewing of reflection color prints or reproductions.

1.3 This standard does not apply to the viewing of projected color transparencies.

Fig. 1
Chromaticity Coordinate Tolerances
About Aim Point

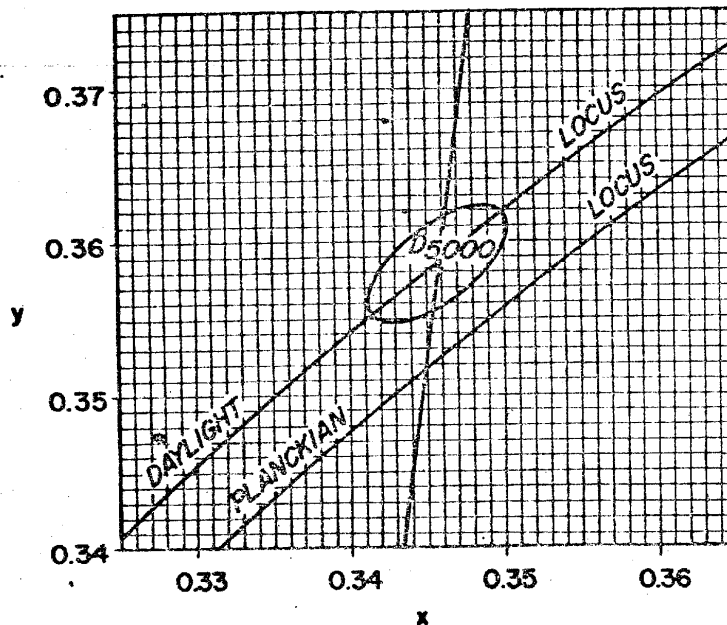


Table 1
Relative Spectral Emittance of Reference
Illuminant D₅₀₀₀

Wavelength (λ)	Relative Emittance (E_{λ})
380 nm	0.245
390	0.298
400	0.493
410	0.565
420	0.600
430	0.578
440	0.748
450	0.872
460	0.906
470	0.914
480	0.952
490	0.920
500	0.957
510	0.966
520	0.971
530	1.021
540	1.008
550	1.023
560	1.000
570	0.977
580	0.989
590	0.935
600	0.977
610	0.993
620	0.990
630	0.957
640	0.988
650	0.957
660	0.982
670	1.030
680	0.991
690	0.874
700	0.916
710	0.929
720	0.768
730	0.866
740	0.926
750	0.782
760	0.577
770	0.829
780	0.783

2. Specifications

2.1 Chromaticity. The chromaticity of the illuminator surface shall be approximately that of a CIE Daylight Illuminant at a correlated color temperature of 5000 K (equivalent to 200 microreciprocal degrees or mireds). The chromaticity

coordinates of the illuminator surface shall lie on the locus of chromaticities corresponding to daylight illuminants [8] (described in Appendix B) at a coordinate position of $x = 0.3457$, $y = 0.3586$, in the 1931 CIE Chromaticity Diagram. The tolerances for variation about this position are shown in Fig. 1 as the ellipse. That ellipse defines a variation in correlated color temperature of approximately five microreciprocal degrees and somewhat less in a direction normal to the axis of variation in correlated color temperature.

2.2 Spectral Power Distribution. The spectral energy characteristics of the illuminator surface shall, ideally, be the same as that of CIE Illuminant D₅₀₀₀. This spectral energy distribution has been tabulated at 10-nm (nanometer) intervals from 380 nm to 780 nm in Table 1.

2.3 General Color Rendering Index. The CIE General Color Rendering Index of the illuminator surfaces shall be measured as specified by the Commission Internationale de l'Éclairage in 1965 [7] and shall have a value of 90 or higher. (cf. Appendix A)

2.4 Luminance. The average luminance of the viewing surface shall be $1400 \text{ cd/meter}^2 \pm 300 \text{ cd/meter}^2$ (408.7 ± 87.6 foot-lamberts) as measured with a luminance meter normal to the surface. The subtense or acceptance angle of the meter should be between two and ten degrees. Luminance values are to be obtained with meters either having a spectral-response function identical with the values tabulated for the CIE "Relative luminous efficiency of monochromatic radiation of wavelength λ " [9] (i.e., the photopic luminosity function) as tabulated in Table 2, or with a response calibrated in terms of values of integration of that function with the light source under test. Any variations from complete uniformity of surface luminance shall be gradual and diminish from center to edge so that the luminance at any point is not less than 60 percent of that measured at the center.

2.5 Diffusion Characteristics. The illuminator surface shall provide diffused light such that the luminance of the surface measured at any angle between 0 to 45 degrees from normal shall not be less than 90 percent of the luminance of the same area as measured normal to the surface.

Table 2
Relative Luminous Efficiency of a Monochromatic
Radiation of Wavelength λ

Wavelength (λ)	Photopic Relative Luminous Efficiency (V_{λ})
380 nm	0.0000
390	0.0001
400	0.0004
410	0.0012
420	0.0040
430	0.0116
440	0.023
450	0.038
460	0.060
470	0.091
480	0.139
490	0.208
500	0.323
510	0.503
520	0.710
530	0.882
540	0.954
550	0.995
560	0.995
570	0.952
580	0.870
590	0.757
600	0.631
610	0.503
620	0.381
630	0.265
640	0.175
650	0.107
660	0.061
670	0.032
680	0.017
690	0.0082
700	0.0041
710	0.0021
720	0.00105
730	0.00052
740	0.00025
750	0.00012
760	0.00006
770	0.00003
780	0.000015

References

- [1] United States of America Standards Institute. *Lighting Conditions for Viewing Photographic Color Prints and Transparencies*, PH2.23-1961. New York: USASI, 1961, pp 8-9.
- [2] Hurvich, L. M., and Jameson, D. *Journal of the Optical Society of America*, vol 41, 1951, p 521.
- [3] Jameson, D., and Hurvich, L. M. *Journal of the Optical Society of America*, vol 41, 1951, p 528.
- [4] Hurvich, L. M., and Jameson, D. *Journal of the Optical Society of America*, vol 41, 1951, p 787.
- [5] Bartleson, C. J., and Witzel, R. F. *Photographic Science and Engineering*, vol 11, 1967, p 329.
- [6] Bartleson, C. J., and Clapper, F. R. *Printing Technology*, vol 11, 1967, p 136.
- [7] Commission Internationale de l'Eclairage. *Method of Measuring and Specifying Colour Rendering Properties of Light Sources*. Paris: CIE Bureau Central, 1965 (Publication No. 13, E-1.3.2).
- [8] Judd, D. B., MacAdam, D. L., and Wyszecki, G. *Journal of the Optical Society of America*, vol 54, 1964, p 1031.
- [9] Commission Internationale de l'Eclairage. *International Lighting Vocabulary*. Paris: CIE Bureau Central, 1957, vol 1, (Publication No. 11), pp 18-21, Table I.

Appendixes

(These Appendixes are not part of Draft USA Standard Direct Viewing of Photographic Color Transparencies, PH2.31, but are included for information purposes only).

Appendix A General Color Rendering Index

Calculation of the CIE General Color Rendering Index [7] (symbolically designated R_a) involves, first, measurement or computation of the CIE 1960 UCS-(Uniform Color Space) chroma-

ticity coordinates of each of eight CIE standard, reflecting, test objects, under the test illumination and under the CIE Daylight Illuminant (cf. Appendix A) of the nearest 100 K correlated

Table A1
Spectral Reflectances of CIE Color Rendering Test Objects
1 Through 8 Used for Determining R_a

λ (nm)	CIE Sample Number							
	1	2	3	4	5	6	7	8
400	0.256	0.111	0.073	0.116	0.313	0.410	0.551	0.336
410	0.252	0.118	0.074	0.124	0.319	0.492	0.559	0.462
420	0.244	0.121	0.074	0.128	0.326	0.517	0.561	0.490
430	0.237	0.122	0.073	0.135	0.334	0.531	0.556	0.482
440	0.230	0.123	0.073	0.144	0.346	0.544	0.544	0.462
450	0.225	0.127	0.074	0.161	0.360	0.556	0.522	0.439
460	0.220	0.131	0.077	0.186	0.381	0.554	0.488	0.413
470	0.216	0.138	0.085	0.229	0.403	0.541	0.448	0.382
480	0.214	0.150	0.109	0.281	0.415	0.519	0.408	0.352
490	0.216	0.174	0.148	0.332	0.419	0.488	0.363	0.325
500	0.223	0.207	0.198	0.370	0.413	0.450	0.324	0.299
510	0.226	0.242	0.241	0.390	0.403	0.414	0.301	0.283
520	0.225	0.260	0.278	0.395	0.389	0.377	0.283	0.270
530	0.227	0.267	0.339	0.386	0.372	0.341	0.265	0.256
540	0.236	0.272	0.392	0.367	0.353	0.309	0.257	0.250
550	0.253	0.282	0.400	0.341	0.331	0.279	0.259	0.254
560	0.272	0.299	0.380	0.312	0.308	0.253	0.260	0.264
570	0.298	0.322	0.349	0.280	0.284	0.234	0.256	0.272
580	0.341	0.335	0.315	0.247	0.260	0.225	0.254	0.278
590	0.390	0.341	0.285	0.214	0.232	0.221	0.270	0.295
600	0.424	0.342	0.264	0.185	0.210	0.220	0.302	0.348
610	0.442	0.342	0.252	0.169	0.194	0.220	0.344	0.434
620	0.450	0.341	0.241	0.160	0.185	0.223	0.377	0.528
630	0.451	0.339	0.229	0.154	0.180	0.233	0.400	0.604
640	0.451	0.338	0.220	0.151	0.178	0.244	0.420	0.648
650	0.450	0.336	0.216	0.148	0.175	0.258	0.438	0.676
660	0.451	0.334	0.219	0.148	0.175	0.268	0.452	0.693
670	0.453	0.332	0.230	0.151	0.180	0.278	0.482	0.705
680	0.455	0.331	0.251	0.158	0.188	0.283	0.468	0.712
690	0.458	0.329	0.288	0.165	0.192	0.291	0.473	0.717
700	0.462	0.328	0.340	0.170	0.199	0.302	0.483	0.721

color temperature. The CIE 1960 UCS chromaticity coordinates may be computed from the CIE 1931 chromaticity coordinates as:

$$u = \frac{4x}{-2x + 12y + 3} \quad (A1)$$

$$v = \frac{6y}{-2x + 12y + 3} \quad (A2)$$

or from the CIE 1931 tristimulus values as:

$$u = \frac{4X}{X + 15Y + 3Z} \quad (A3)$$

$$v = \frac{6Y}{X + 15Y + 3Z} \quad (A4)$$

where

u, v = CIE 1960 UCS chromaticity coordinates
 x, y = CIE 1931 chromaticity coordinates
 X, Y, Z = CIE 1931 tristimulus values.

The spectral reflectances of the eight test objects are listed in Table A1 at 10-nm (nanometer) intervals from 400 nm to 700 nm. Each of these spectral reflectances should be multiplied by the spectral power of the test source (i.e. the illuminator surface) at each wavelength. The resultant spectral distributions should each be integrated with the CIE distribution coefficients $\bar{x}, \bar{y}, \bar{z}$, or $\bar{u}, \bar{v}, \bar{w}$, to determine each of the eight CIE 1960 UCS chromaticity coordinates. In addition, each of the eight spectral reflectance distributions should be multiplied at each wavelength by the spectral emittance at each wavelength of the CIE Daylight Illuminant of the nearest 100 K correlated color temperature and the resultant spectral distributions should each be integrated with the CIE spectral distribution coefficients $\bar{x}, \bar{y}, \bar{z}$, or $\bar{u}, \bar{v}, \bar{w}$, to determine the CIE 1960 UCS chromaticity coordinates. Root mean square differences among corresponding sets of chromaticity coordinates define the chromaticity differences to be used in computing R_a .

Table A2
CIE Color Difference Vector Magnitudes Corresponding to One Percent Increments of R_a

R_a (Percent)	$\Delta \bar{E}_{u,v}$	$\Delta \bar{E}_a$	R_a	$\Delta \bar{E}_{u,v}$	$\Delta \bar{E}_a$	R_a	$\Delta \bar{E}_{u,v}$	$\Delta \bar{E}_a$	R_a	$\Delta \bar{E}_{u,v}$	$\Delta \bar{E}_a$
100	0.0000	0.0	75	0.0068	5.4	50	0.0136	10.8	25	0.0204	16.3
99	0.0003	0.2	74	0.0071	5.6	49	0.0139	11.1	24	0.0207	16.5
98	0.0005	0.4	73	0.0073	5.9	48	0.0141	11.3	23	0.0209	16.7
97	0.0008	0.7	72	0.0076	6.1	47	0.0144	11.5	22	0.0212	16.9
96	0.0011	0.9	71	0.0079	6.3	46	0.0147	11.7	21	0.0215	17.1
95	0.0014	1.1	70	0.0082	6.5	45	0.0150	11.9	20	0.0217	17.4
94	0.0016	1.3	69	0.0084	6.7	44	0.0152	12.2	19	0.0220	17.6
93	0.0019	1.5	68	0.0086	6.9	43	0.0155	12.4	18	0.0223	17.8
92	0.0022	1.7	67	0.0090	7.2	42	0.0158	12.6	17	0.0226	18.0
91	0.0024	2.0	66	0.0092	7.4	41	0.0160	12.8	16	0.0228	18.2
90	0.0027	2.2	65	0.0095	7.6	40	0.0163	13.0	15	0.0231	18.4
89	0.0030	2.4	64	0.0098	7.8	39	0.0166	13.2	14	0.0234	18.7
88	0.0033	2.6	63	0.0101	8.0	38	0.0168	13.5	13	0.0236	18.9
87	0.0035	2.8	62	0.0103	8.2	37	0.0171	13.7	12	0.0239	19.1
86	0.0038	3.0	61	0.0106	8.5	36	0.0174	13.9	11	0.0242	19.3
85	0.0041	3.3	60	0.0109	8.7	35	0.0177	14.1	10	0.0245	19.5
84	0.0044	3.5	59	0.0111	8.9	34	0.0179	14.3	9	0.0247	19.8
83	0.0046	3.7	58	0.0114	9.1	33	0.0182	14.5	8	0.0250	20.0
82	0.0049	3.9	57	0.0117	9.3	32	0.0185	14.8	7	0.0253	20.2
81	0.0052	4.1	56	0.0120	9.6	31	0.0188	15.0	6	0.0255	20.4
80	0.0054	4.3	55	0.0122	9.8	30	0.0190	15.2	5	0.0258	20.6
79	0.0057	4.6	54	0.0125	10.0	29	0.0193	15.4	4	0.0261	20.8
78	0.0060	4.8	53	0.0128	10.2	28	0.0195	15.6	3	0.0264	21.0
77	0.0062	5.0	52	0.0130	10.4	27	0.0198	15.8	2	0.0266	21.3
76	0.0065	5.2	51	0.0133	10.6	26	0.0201	16.1	1	0.0269	21.5
—	—	—	—	—	—	—	—	—	0	0.0272	21.7

The value of R_a can be determined as:

$$R_a = 100 - 4.6 \overline{\Delta E_a} \quad (A5)$$

where

$$\overline{\Delta E_a} = \frac{\sum \Delta E_a}{8} \quad (A6)$$

and

$$\Delta E_a = 800 \left[[(u_{k,i} - u_k) - (u_{o,i} - u_o)]^2 + [(v_{k,i} - v_k) - (v_{o,i} - v_o)]^2 \right]^{1/2} \quad (A7)$$

where

$u_{k,i}$ and $v_{k,i}$ = CIE 1960 UCS chromaticity coordinates of the test samples ($i = 1$ through 8) under the sample light source (k)

$u_{o,i}$ and $v_{o,i}$ = CIE 1960 UCS chromaticity coordinates of the test samples ($i = 1$ through 8) under the reference CIE Daylight Illuminant (o)

u_k and v_k = CIE 1960 UCS chromaticity coordinates of the sample light source (k)

u_o and v_o = CIE 1960 UCS chromaticity coordinates of the reference CIE light Illuminant (o).

Alternatively, the value of ΔE_a may be determined by:

$$\Delta E_a = 800 [(u_{o,i} - u_{k,i})^2 - (v_{o,i} - v_{k,i})^2]^{1/2} \quad (A8)$$

where

$$\begin{aligned} u'_{k,i} &= u_{k,i} + (u_o - u_k) \\ v'_{k,i} &= v_{k,i} + (v_o - v_k) \end{aligned} \quad (A9)$$

It is also mentioned that:

$$R_a = 100 - 3.7 (10^3) (\overline{\Delta E_{u,v}}) \quad (A10)$$

where

$$\overline{\Delta E_{u,v}} = \frac{\overline{\Delta E_a}}{800} \quad (A11)$$

in which $\overline{\Delta E_{u,v}}$ represents the average value of $\Delta E_{u,v}$ vectors for test samples 1 through 8 on the CIE 1960 UCS diagram and $\overline{\Delta E_a}$ represents these same values after adjustment to provide units in which a one-percent difference corresponds on the average to approximately one just-perceptable color difference.

Values of $\overline{\Delta E_{u,v}}$ and $\overline{\Delta E_a}$ are listed for one percent increments of R_a in Table A2.

Appendix B

Definition of CIE Daylight Illuminants

CIE Daylight Illuminants are defined by the following rules:

(1) **Chromaticity.** The CIE 1931 chromaticity coordinates of the daylight (*D*) illuminant must satisfy the following relation:

$$y_D = -3.000x_D^2 + 2.870x_D - 0.275 \quad (\text{B1})$$

with x_D being within the range of 0.250 to 0.380.

(2) **Correlated Color Temperature (T_c).** T_c (in K) of daylight (*D*) illuminants from 4000 K to 7000 K is related to x_D by the following formula:

$$x_D = -4.5993 \frac{10^3}{T_c^3} + 2.9645 \frac{10^6}{T_c^2} \quad (\text{B2})$$

$$+ 0.09905 \frac{10^3}{T_c} + 0.244063$$

(3) **Relative Spectral Power Distribution (S_λ).** Values of S_λ for daylight (*D*) illuminants are to be computed from the following equation:

$$S_\lambda = S_{0,\lambda} + M_1 S_{1,\lambda} + M_2 S_{2,\lambda} \quad (\text{B3})$$

where $S_{0,\lambda}$, $S_{1,\lambda}$, and $S_{2,\lambda}$ are functions of wavelength, λ , given in Table B1 and M_1 , M_2 are factors relating to the chromaticity coordinates x_D , y_D as follows:

$$M_1 = \frac{-1.3515 - 1.7703x_D + 5.9114y_D}{0.0241 + 0.2562x_D - 0.7341y_D} \quad (\text{B4})$$

$$M_2 = \frac{0.0300 - 31.4424x_D + 30.0717y_D}{0.0241 + 0.2562x_D - 0.7341y_D} \quad (\text{B5})$$

To facilitate the practical use of these recommendations, values of x_D , y_D , u_D , v_D , M_1 , and M_2 are given for 100 K intervals of T_c from 4000 K to 6000 K in Table B2.

B1
Spectral Power Eigenvectors
as a Function of Wavelength

λ (nm)	$S_{0,\lambda}$	$S_{1,\lambda}$	$S_{2,\lambda}$
300	0.4	0.2	0.0
310	80	45	20
320	296	224	40
330	553	420	85
340	573	406	78
350	618	416	67
360	615	380	53
370	688	424	61
380	634	385	30
390	658	350	12
400	948	434	-11
410	1048	463	-5
420	1059	439	-7
430	968	371	-12
440	1139	367	-26
450	1256	359	-29
460	1265	326	-28
470	1213	279	-26
480	1213	243	-26
490	1135	201	-18
500	1131	162	-15
510	1108	132	-13
520	1065	86	-12
530	1088	61	-10
540	1053	42	-5
550	1044	19	-3
560	1000	0	0
570	960	-16	2
580	951	-35	5
590	891	-35	21
600	905	-58	32
610	903	-72	41
620	884	-86	47
630	840	-95	51
640	851	-109	67
650	819	-107	73
660	826	-120	86
670	849	-140	98
680	813	-136	102
690	719	-120	83
700	743	-133	96
710	784	-129	85
720	633	-106	70
730	717	-116	76
740	770	-122	80
750	662	-102	67
760	477	-78	52
770	696	-112	74
780	650	-104	68
790	660	-106	70
800	610	-97	64
810	533	-83	55
820	589	-93	61
830	619	-98	65

Table B2
Illuminant D Parameters as a
Function of Color Temperature

T_C	x_D	y_D	u_D	v_D	M_1	M_2
4000	0.3822	0.3837	0.2235	0.3366	-1.504	2.818
4100	0.3778	0.3811	0.2217	0.3354	-1.464	2.452
4200	0.3736	0.3785	0.2199	0.3342	-1.421	2.120
4300	0.3696	0.3759	0.2183	0.3331	-1.377	1.818
4400	0.3657	0.3734	0.2167	0.3319	-1.332	1.544
4500	0.3820	0.3708	0.2153	0.3308	-1.285	1.296
4600	0.3584	0.3683	0.2139	0.3297	-1.237	1.070
4700	0.3550	0.3658	0.2126	0.3286	-1.188	0.866
4800	0.3518	0.3634	0.2114	0.3275	-1.139	0.681
4900	0.3487	0.3610	0.2102	0.3265	-1.089	0.514
5000	0.3457	0.3586	0.2091	0.3254	-1.039	0.363
5100	0.3428	0.3563	0.2081	0.3244	-0.988	0.226
5200	0.3400	0.3540	0.2071	0.3234	-0.937	0.103
5300	0.3374	0.3518	0.2061	0.3224	-0.886	-0.008
5400	0.3349	0.3497	0.2053	0.3115	-0.836	-0.108
5500	0.3324	0.3475	0.2044	0.3205	-0.785	-0.198
5600	0.3301	0.3455	0.2036	0.3196	-0.734	-0.278
5700	0.3278	0.3435	0.2028	0.3187	-0.684	-0.350
5800	0.3257	0.3415	0.2021	0.3178	-0.634	-0.414
5900	0.3236	0.3396	0.2014	0.3170	-0.584	-0.471
6000	0.3216	0.3377	0.2007	0.3161	-0.535	-0.521